HURRICANE SURVEY

INTERIM REPORT

MYSTIC

CONNECTICUT

APPENDICES

U.S. Army Engineer Division, New England
Corps of Engineers
Boston, Mass.

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GLOSSARY

BUILDUP BELOW BARRIER: the increase in water surface elevation in feet immediately downstream from the barrier resulting from construction of the barrier.

HURRICANE SURGE: the mass of water causing an increase in the elevation of the water surface above predicted astronomical tide at the time of a hurricane; it includes wind setup; sometimes the maximum increase in elevation is referred to as the surge.

HURRICANE TIDE: the rise and fall of the water surface during a hurricane exclusive of wave action.

KNOT: a velocity equal to one nautical mile (6080.2 feet) per hour (about 1.15 statute miles per hour).

OVERTOPPING: that portion of the wave runup which goes over the top of a protective structure.

PONDING: the storage of water behind a dike or wall from local runoff and/or overtopping by waves.

POOL BUILDUP: the increase in elevation of water surface behind a structure due to runoff and/or overtopping by waves.

RUNUP: the rush of water up the face of a structure on the breaking of a wave. The height of runup is measured from the stillwater level.

SIGNIFICANT WAVE: a statistical term denoting waves with the average height and period of the one-third highest waves of a given wave train.

SPRING TIDE: a tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.

STANDARD PROJECT HURRICANE: A storm that may be expected from the most severe combination of meteorologic conditions that are considered reasonably characteristic of the region involved, excluding rare combinations.

STILLWATER LEVEL: the elevation of the water surface if all wave action were to cease.

STORM SURGE: same as "hurricane surge".

GLOSSARY (Cont'd)

WAVE HEIGHT: the vertical distance between the crest and the preceding trough.

WAVE TRAIN: a series of waves from the same direction.

WIND SETUP: the vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water.

APPENDIX A

HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES

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HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES

A-1. GENERAL

In order to determine the possibility of future hurricane occurrences, a review has been made of historical data on hurricanes that have struck or threatened the coast of Connecticut. A review of historical records and newspaper files indicates that a number of hurricanes and cyclonic storms have reached the coast of southern New England with devastating force, while numerous other storms have passed so close that a slight change in meteorologic conditions could have resulted in severe damage. Since the eastern entrance of Long Island Sound lies in the path of hurricanes moving into New England from the south, the Connecticut shoreline, on the north of the Sound, has frequently been subject to tidal flooding from hurricane surges moving west up the Sound. The records indicate that from 1770 to present the Connecticut coast has experienced or has been threatened by hurricane tidal flooding upon 58 occasions. About 28 of these hurricanes, passing some distance away, did not cause tidal flooding along the Connecticut coast, however, they did present a potential threat of such flooding. Apparently 30 hurricanes caused significant tidal flooding. Existing records indicate that the five hurricanes which have created the most severe tidal flooding along the Connecticut coast are as follows, chronologically:

15 September 1815
24 August 1893
21 September 1938
14 September 1944
31 August 1954

The earliest hurricanes recorded in New England are known to have affected the coastal areas of Massachusetts and Rhode Island. Since there was very little development along the Connecticut shore until after 1638, there are no available records to indicate that these early storms affected Long Island Sound. It is reasonable to assume that they did cause inundation of the coastal lowlands of Connecticut, as the hurricanes of recent years that have caused tidal flooding along the coasts of southern Massachusetts and Rhode Island also caused flooding along the Connecticut coast. The two earliest hurricanes of record in New England, namely those of 15 August 1635 and 3 August 1638, created flood levels apparently higher than the recent floods of 1938 and 1954, and probably the greatest experienced in New England during the past 320 years.

The early hurricanes were not accompanied by so great a loss of life and property due to the lesser degree of development along the Connecticut coast. However, the recurrence of the two earliest hurricanes under present conditions would cause extensive damages, possibly in excess of the damages sustained in September 1938.

In addition to the above hurricanes, there have been other severe storms, not necessarily of tropical origin, that caused considerable damage along the Connecticut coast (see Table A-2). An examination of the U. S. Coast and Geodetic Survey tide-gage records of New London Harbor, Connecticut, which is located about 6 miles west of Mystic and has about the same mean tide range as Mystic Harbor, indicates that there have been 18 occasions, other than hurricane experiences, during the period July 1938 through December 1956, when storms or other meteorologic conditions caused the tide at Mystic Harbor to reach an elevation of 3.8 feet, m.s.l. or higher. This elevation is approximately 1.4 feet above the level that would be reached in a high gravitational spring tide. The five highest tides so experienced at Mystic Harbor (as estimated from New London tide-gage records) during this 18.5-year period are tabulated below:

Date	Tide (ft. m.s.l.)
25 Nov. 1950	6.6
7 Nov. 1953	5.8
12 Nov. 1947	4.8
3 Mar. 1942	4.6
30 Nov. 1944	4.5

A-2. SUMMARY OF HURRICANES

A total of 58 hurricanes which are known to have either hit or narrowly missed the Connecticut coast is summarized in Table A-1. These hurricanes have been classified to indicate their magnitude along the Connecticut coast as follows:

Type "A": Hurricanes causing severe tidal flooding.
Type "B": Hurricanes causing damage from wind and rainfall (usually accompanied by high seas and moderate tidal flooding).
Type "C": Hurricanes threatening the area.

Of the 58 hurricanes, 15 are of type "A", 15 of type "B", and 28 of type "C". Thirty-eight of the listed hurricane experiences have occurred during the period from 1901 to 1956. The fact that there is a record of 38 hurricanes in this 56-year period, as compared with 20 in the 131-year

period from 1770 to 1900, is not considered indicative of a greater trend in hurricane activity in recent years but to a lack of records and information on storms prior to 1900.

TABLE A-1

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1635, Aug. 15	-	(2)(3)	Great tidal surge along coast of R.I. Records do not indicate effect on Conn. coast
1638, Aug. 3	-	(3)	Historical account indicates greatest tidal flooding ever experienced along Mass. and R.I. coast. Records do not indicate effect on Conn. coast.
1641, Nov. 12	-	(3)	A great tide along the coast of Mass. Records do not indicate effect on Conn. Coast.
1723, Oct. 31	-	(3)	Very high tides in R.I.; considerable damage. Records do not indicate effect on Conn. coast.
1757, June 30 .	-	(2)	Atlantic coast hurricane, Florida to Boston, Mass. Records do not indicate effect on Conn. coast.
1761, Oct. 24	-	(3)	Very high tides in Narragansett Bay, R.I. Damage from wind and water. Records do not indicate effect on Conn. Coast.
1770, Oct. 19-20	A	(3)	A violent storm; immense loss of life and property along the coast. Report of boat damage at New London, Conn.

(Footnotes are at end of Table)

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1773, Aug. 19	C	(2)(3)	Passed near Boston, Mass. "Abundant showers" in Conn.
1787, Sept. 19	B	(3)	Reports of damage at Stamford and Norwalk, Conn.
1788, Aug. 19	B	(2)	Affected western New England much wind and rain damage in Conn. and western Mass.
1804, Sept. 3-9	C	(2)	Severe storm; passed over Cape Cod, travelling northeast. No account of damage in Conn.
1804, Oct. 9-10	B	(2)(3)	Reports of wind and rain damage.
1815, Sept. 22-23	A	(2)(3)(5)	Severe damage along Conn. coast from tidal flooding. Tide 1 ft. higher than 1938 and 2 ft. higher than 1954 at Pawcatuck, Conn.
1821, Sept. 2-3	A	(2)(3)	Wind damage to boats and homes. Tidal flood damage at New London Conn.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1829, July 24	C	(2)(3)	Reported to have been felt in Boston, Mass. No accounts of damage in Conn.
1841, Oct. 4	B	(2)(3)	Violent winds and heavy rain; reports of wind damage at Hartford, Conn.
1854, Sept. 10-11	C	(2)(3)	Severe in southern states; passed over New England, near Boston. Described as "an old fashioned rain-storm."
1866, Oct. 29-30	B	(2)(3)	Reports of wind damage.
1869, Sept. 8	A	(2)(3)	Tidal flooding at Mystic, Conn.
1877, Oct. 5	C	(2)(3)	Path was south of Long Island and Nantucket. No accounts of damage in Conn.
1878, Oct. 23	A	(2)(3)	Reports of wind damage and very high tides along Conn. coast.
1879, Aug. 18	B	(2)	Passed over Cape Cod. Damage from wind and rain along Conn. coast
1889, Sept. 10	A	(2)(3)	Streets in Stamford flooded by heavy rain. Very high tide at Greenwich Conn. Minor damage due to waves at Mystic.

TABLE A-1 (Continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1893, Aug. 23-24	A	(2)(3)	Wind, rain, and high tide caused damage along Conn. coast.
1893, Aug. 29	A	(3)	Reports of damage from wind and tide along Conn. coast.
1896, Sept. 9-10	B	(2)(3)	Strong winds and heavy rains along Conn. coast.
1901, Sept. 12	C	(2)(4)	Passed south and east of Cape Cod.
1902, June 11-20	C	(2)(3)(4)	Path crossed Buzzards Bay and Cape Cod, moving northeast. Strong winds over L.I. Sound.
1902, June 29	C	(2)	Center passed over Conn. and southern R.I. traveling southeast; no account of damage.
1902, Oct. 7-13	C	(2)(3)(4)	Path south of Long Island and Nantucket, moving east. Heavy rain and high wind at New Haven, Conn. but no accounts of any damage along the Conn. coast.
1903, Sept. 16	A	(2)(3)	Storm crossed northeastern Pa., moving northwest. High winds and high water along Conn. coast.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1904, Sept. 15	B	(2)(3)	Center passed over northeastern Conn., moving northeast. Reports of rain and wind damage and heavy surf.
1904, Nov. 9-14	B	(2)(4)	Passed south of Nantucket, moving northeast. Reports of wind damage.
1911, Aug. 29-30	C	(2)	Passed south of Cape Cod. No accounts of damage in Connecticut.
1912, Sept. 11-23	C	(2)	Followed easterly path across southern New England.
1916, July 21	C	(2)(4)	Passed over Providence, R.I., heading northeast. Reports of wind and rain damage in Connecticut.
1920, Oct. 1	A	(2)(3)(4)	Storm passed just west of New York, heading north. Reports of damage from high tides along Conn. coast.
1923, Oct. 14-19	C	(2)(4)	Passed near Boston, moving northwest. Storm of slight energy.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1924, Aug. 26	B	(2)(3)	Crossed east tip of Cape Cod, moving northeast. Some damage from strong winds.
1929, Oct. 3	A	(2)(4)	Moved northeast, passing over eastern New York and northwestern Vermont. High tides caused damage along Connecticut coast.
1933, Aug. 23-24	A	(2)(3)(4)	Driving rain and high tides along Conn. coast.
1933, Sept. 10-16	C	(2)(3)	Passed south of Cape Cod, moving northeast. No reports of damage in Conn.
1934, June 4-21	C	(2)	Travelled overland from Louisiana; crossed Long Island and Cape Cod, moving northeast.
1934, Sept. 9	B	(2)(4)	Crossed Long Island and central Conn. moving north. Wind damage along Conn. coast.
1936, Sept. 19	B	(2)(3)(4)	Passed south of Nantucket heading northeast. Wind damage along Conn. coast.
1938, Sept. 21	A	(2)(3)(4)	Most damaging storm to strike southern New England. Tidal-flooding along entire Conn. coast. 9-foot surge at New London.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1940, Sept. 2-3	C	(2)	Passed south of Nantucket, heading northeast. No accounts of damage in Conn.
1940, Sept 11-18	C	(2)(4)	Followed northeasterly path east of Cape Cod. No accounts of damage.
1943, Oct. 17	C	(2)(4)	Passed east of Cape Cod, moving due north. No accounts of damage.
1944, Aug. 3-4	C	(2)(4)	Moved northeasterly along path south of Long Island and Nantucket. No accounts of damage.
1944, Sept. 14-15	A	(2)(3)	Center passed over Providence, R.I. and south of Boston, Mass. Tidal-flooding along entire Conn. coast; 6.2 feet, msl New London.
1944, Oct. 21	C	(2)(4)	Path crossed over Nantucket and easterly tip of Cape Cod. No accounts of damage.
1945, June 26	C	(2)(4)	Followed northeasterly path from Florida to Nova Scotia, passing south of Nantucket.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	Category (1)	Source of Data	Remarks
1945, Sept. 19	C	(2)(4)	Overland from Florida; passed just west of New York, moving northeast.
1949, Aug. 29	C	(2)(3)(4)	Travelled overland from northern Florida, crossed center of Maine. High winds at Greenwich, Conn.
1950, Aug. 20	C	(2)(4)	Passed south of Nantucket, heading generally northeast. Heavy rain at Greenwich, Conn.
1950, Sept. 11	C	(2)(3)	Passed south and east of Nantucket, then headed east. No reports of damage in Conn.
1952, Sept. 1 ("Able")	C	(2)	Followed northeasterly track, approximately over New York. Heavy rain and high wind at Greenwich, Conn.
1953, Aug. 15 ("Barbara")	C	(2)(4)	Followed path south of Long Island and Nantucket.
1953, Sept. 7 ("Carol")	C	(2)	Passed east of Cape Cod heading generally north.

TABLE A-1 (continued)

HISTORICAL HURRICANES

CONNECTICUT COAST

Date of Hurricane	(1) Category	Source of Data	Remarks
1954, Aug 31 ("Carol")	A	(2)(3)(4)	Second most damaging storm to hit Conn. coast. Crossed east end of Long Island moving north; 8.9 feet, m.s.l. at New London.
1954, Sept 11 ("Edna")	B	(2)(3)	Passed over Cape Cod, heading northeast. High seas, minor damage from wind.
1954, Oct.5-16 ("Hazel")	B	(4)	Moderate to heavy rains in New England. Peak gusts reached gale and whole gale force.
1955, Aug. 5 ("Connie")	C	(3)(4)	Caused scare in New England and heavy rainfall but no damage. Storm passed southwest of Washington, D. C.
1955, Aug. 18 ("Diane")	B	(2)(3)	Passed just south of Long Island and about over Nantucket. Brought record rainfall to many areas of Conn.; heavy flood damage in river valleys; no important tidal-flood damage along coast.
1955, Sept. 11 ("Ione")	C	(3)(4)	Caused scare in New England but no reported damage. Storm turned east and then northeast after passing inland of Cape Hatteras.
1958, Aug 25 ("Daisy")	C	(3)(4)	Caused scare in New England but no damage. South of Nantucket Island the storm turned east and then northeasterly.

NOTES

(1) The following assigned categories pertain to the effect of a hurricane on the coast of Connecticut.

A: Caused severe tidal flooding.

B: Caused damage from wind and rainfall (usually accompanied by high seas and moderate tidal flooding).

C: Threatened the area.

Notes.(cont).

(2) "Hurricanes - Their Nature and History," by I.R. Tannehill (1956).

(3) Local newspaper accounts, histories, etc.

(4) Material furnished by U.S. Weather Bureau.

(5) Information furnished at public hearing at Pawcatuck, Conn.

TABLE A-2

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES ALONG THE CONNECTICUT COAST

Date of Storm	Remarks
1639, March 16	"There was so violent a wind at south-southeast and south as the like was not since we came into this land. It began in the evening, and increased till midnight. It overturned some new strong houses; . . . It tare down fences - people ran out of the houses in the night, . . . There came such a rain withal, as raised the waters at Connecticut 20 feet above their meadows, etc. (Winthrop's Journal "History of New England, 1630-1649".)
1767, Jan. 12	"A great variety of articles have been found on the north side of Long Island supposed to have drifted from this colony (New London), in the late great freshet, among which are boats, timber, parts of houses, stacks of hay, etc." (The Massachusetts Gazette and Boston Weekly News-Letter.)

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES ALONG THE CONNECTICUT COAST

Date of Storm	Remarks
1767, Dec. 14	"From the southward we hear, that the gales . . . did considerable damage to the wharves and shipping at Newport, Stonington, New London, etc. The tides rose higher than had been known for many years in those places. . . Eleven sail bound up the sound were drove ashore at Stonington . . . It is said, the wind, which was at west-southwest was the most violent ever known along that coast." (The Massachusetts Gazette and Boston Weekly News-Letter, No. 3351.)
1771, Feb. 9	"Last Saturday morning came on a storm of snow and hail, which soon changed to rain, and the wind varying to the southeast brought into the harbor (New Haven) the fullest tide ever known, which ebbed and flowed two or three feet in a few minutes; and at the time it was expected to be low water, the tide was above high water mark. Great quantities of lumber were floated from the wharves, and a great deal of sugar, salt, etc. destroyed. A Brig and two sloops were drove ashore in the harbor". (The Massachusetts Gazette and Boston Weekly News-Letter, No. 3513.

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES ALONG THE CONNECTICUT COAST

Date of Storm	Remarks
1869, Oct. 3	"A fearful gale prevailed all yesterday along the Atlantic border and even carried its disasterous effects far into the interior. The rain fell in torrents, and great damages by floods are reported from every quarter." (Norwich Morning Bulletin.)
1895, Feb 7	"During the gale and high tide here (Stonington) Friday . . . The water flooded the engine room of the Atwood Machine Company. This is something that was never known to happen before. The damage at Eastern Point is more extensive than was first thought. People at the Point say they never before experienced such gales and such tremendous seas. The wharves will all have to be repaired. Some of the dwelling houses too present a very bedrabbled appearance." (The Day, New London, Conn.)
1896, Feb. 9-10	"The worst northeast storm of the season . . . has raged here (New London) all day. The surf is higher than it has been since the spring storms . . . The rainfall from its commencement Thursday up to 3:00 today (Friday) amounted to 5.16 inches and at that time was falling at

TABLE A-2 (continued)

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDES ALONG THE CONNECTICUT COAST

Date of Storm	Remarks
	the rate of three fourths of an inch an hour . . . The usual channels towards the river in all parts of the city have been overtaxed causing the water to set back and overflow the roads, meadows, yards, etc. and converting many of the cellars into lakes. From Bloomingdale back for a long distance the country is flooded and the roads covered with water to a depth of a foot in many places." (The Day, New London, Connecticut)
1942, March 3	Tide rose to 4.7 feet above mean sea level at New London, Conn.
1942, Dec. 2	Tide rose to 4.4 feet above mean sea level at New London, Conn.
1944, Nov. 30	Tide rose to 4.6 feet above mean sea level at New London, Conn.
1947, Nov. 12	Tide rose to 4.9 feet above mean sea level at New London, Conn.
1950, Nov. 25	Tide rose to 6.7 feet above mean sea level at New London, Conn.
1951, Nov. 3	Tide rose to 4.3 feet above mean sea level at New London, Conn.
1953, Nov. 7	Tide rose to 5.9 feet above mean sea level at New London, Conn.
1956, Mar. 16	" Tides reminiscent of those during all hurricanes ran abnormally high at Jupiter Point and Groton Long Point". (The Day, New London.). The tide at New London rose to 4.5 feet above msl.

A-3. *DESCRIPTIONS*

Brief descriptions of type "A" and "B" hurricanes experienced along the Connecticut coast, as reported in newspaper accounts, or obtained from other records, are given below. Also included are descriptions of six hurricanes (Category "A") that are reported to have struck Rhode Island and Massachusetts and which are believed to have affected Connecticut but for which no records have been found regarding their effect on the Connecticut coast.

a. 15 August 1635. From: "Of Plymouth Plantation, 1620-1647," by William Bradford.

> "This year the 14 or 15 of August (being Saturday) was such a mighty storm of wind and rain, as none living in these parts either English or Indian, ever saw, being like (for the time it continued) to those Hauricanes and Tuffons that writers make mention of in the Indies. It began in the morning, a little before day, and grew not by degrees, but came with violence in the beginning to the great amazement of many. It blew down sundry 211 houses, and uncovered others; divers vessels were lost at sea, and more in danger. It caused the sea to swell (to southward of this place) about 20 feet, right up and down, and made many of the Indians to climb into trees for their safety; it took off the board roof of a house which belonged to this plantation at Manamet, and floated it to another place, the posts still standing in the ground; and if it had continued long without the shifting of the wind, it is like it would have drowned some part of the country. It blew down many hundred thousands of trees, turning up the stronger by the roots, and breaking the higher pine trees off in the middle, and the tall young oaks and walnut trees of good bigness were wound like a withe, very strange and fearful to behold. It began in the southeast and parted toward the south and east, and veered sundry ways; but the greatest force of it here was from the former quarters. It continued not (in the extreme) above 5 or 6 hours, but the violence began to abate. The signs and marks of it will remain this 100 years in these parts where it was sorest. The moon suffered a great eclipse in the second night after it."

From: "The History of New England from 1630 to 1649," by John Winthrop.

> " ... This tempest was not so far as Cape Sable, but to the south more violent, and made a double tide all that coast ....

"The tide rose at Narragansett fourteen feet higher than ordinary and drowned 8 Indians flying from their wigwams."

b. 3 August 1638. From: "The History of New England from 1630 to 1649", by John Winthrop.

"In the night was a very great tempest or hiracano at Southwest which drave a ship on ground at Charlestown, and brake down the windmill there, and did much other damage. It flowed twice in 6 hours, and about Narragansett it raised the tide 14 to 15 feet above the ordinary spring tides, upright."

c. 12 November 1641. From: "The History of New England from 1630 to 1649", by John Winthrop.

"A great tempest of wind and rain from the southeast all the night, as fierce as an hurricane. It continued very violent at Northwest all the day after. Divers boats and one bark were cast away in the harbor, but (which was a wonder to all) no dwelling house blown down, nor any person killed; and the day after it came to southeast again, and continued all the night with much wind and rain; and thereupon (it being about the new moon) followed the highest tide which we had seen since our arrival here."

d. 30 October 1723. From: "The Boston News-Letter, No. 1033. Thursday November 27 to Thursday November 14, 1723."

"Rhode Island, November 1 ....

"....On Wednesday last we had here a very great Southeast storm of wind and rain, and a very high tide, a foot higher than ever was known before, which has broken and carried away several of our wharves, and drove some vessels ashore from their anchors, and has done considerable damage in warehouses and cellars, to dry goods and other merchandise; the loss is computed to some thousand pounds."

e. 24 October 1761. From: "The Boston News-Letter No. 2991. Thursday, October 29, 1761."

"There was a hard gale of wind which brought the highest tide into the harbor of Providence in Rhode Island that hath been known in the memory of man, and carried away the great or Weybosset Bridge. Five or six vessels were drove ashore and greatly damaged, and it being high water there, it got into the stores and cellars and damaged sugars, etc. to the amount

of 12 or 15000 pounds their currency. On both roads East and West, so far as we have heard, the roofs of houses, tops of barns and fences, have been blown down, and it is said thousands of trees have been torn up by the roots by the violence of the above storm, and we fear we shall hear melancholy accounts of damage done at sea."

From: "Memoirs of Rhode Island 1636-1783", by Henry Bull.

"From the Newport Mercury of October 27, 1761 - On Friday last came on a terrible storm from the Northeast, which continued increasing with a very heavy rain, and did not abate till after 2 in the morning. The violence of the wind broke off part of the steeple of the Trinity Church. Several persons sustained considerable loss in their sugar, salt, etc. by the prodigious rise of tide, which flowed into their stores and cellars. Many of the ships in the harbor were driven ashore from the wharves and their moorings, but without any considerable damage except to two ships. Sad havoc has been made with the lumber and wood on the wharves, great quantities of fence blown down and numbers of trees torn up by the roots. People hardly thought themselves safe in their own houses, for a more violent storm has scarce ever been known here."

f. 19-20 October 1770. (Type "A") "History of the State of Rhode Island", by Samuel Greene Arnold.

"A violent storm again blew down a part of the spire of Trinity Church at Newport and caused an immense loss of life and property along the coast. Newport suffered very severely in this gale."

From: "The Connecticut Journal", November 21, 1770.

"New London, Oct. 26

"On Friday Night and part of the next day we had a very severe Storm of Wind and Rain from the N.E. by which two Vessels were drove ashore in this Harbor but received little or no damage."

g. 19 September 1787. (Type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut 1699-1870."

"Line storm. A mill at Stamford carried off whole and Norwalk bridge floted."

h. 19 August 1788. (Type "B") From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut 1699-1870."

> "The hardest gale that has been for many years -- at 1 o'clock a Sloop and Schooner went on shore---. The Gale reached 100 miles up country, in some places shifting from SE to NW & twisting of trees 9 inches in diameter--it moved Carson's house about 6 feet."

From: "The New-Haven Gazette and the Connecticut Magazine," Thursday, August 21, 1788.

> "New Haven.
>
> "Last Tuesday morning came on a violent gale of wind from the South, which at about one o'clock, P.M. veered to S.S.W. and blew a perfect hurricane.
>
> "Several vessels were driven ashore and very material damage is done to the long Wharf---We expect to hear of much damage done at sea and in the harbours on our coast..."

From: "The Connecticut Courant and Weekly Intelligence," Monday, August 25, 1788.

> "New Haven, Aug. 20.
>
> "Yesterday we had a violent gale of wind, the height of which was from the S.E. about one o'clock. Though the tide was not full as has been frequent in easterly storms, considerable damage was done to the Long-Wharf by the violence of the waves and several vessels parted their masts, but the shipping received no material damage. The Indian corn is much injured and the trees stripped of their fruit and some apple trees blown down."

i. 9-10 October 1804. (Type "B"). From: "The Connecticut Courant," (October 17).

> "The partial and summary accounts which have been received from the neighboring towns, though they afford no particulars of the effects of the late gale, sufficiently evince the widespread destruction which has been experienced by it. In all most every direction the

fruit and other trees have been generally blown down, the fences destroyed and much damage done by the heavy rain, which fell during the storm."

j. 22-23 September 1815. (Type "A"). *From:* "Connecticut Herald," (New Haven) September 26.

"The storm. -- On Friday night and Saturday morning last a severe storm of wind and rain was experienced in this vicinity...The most material injury sustained here was to Long Wharf, which was entirely inundated by the highest tide known for a great number of years. Everything movable on the wharf was swept away. The water in some of the stores was nearly two feet deep, but no great loss of property took place except in a quantity of rum which was swept from the wharf, several hogshead of which have not yet been recovered..."

From: "The Connecticut Courant," October 4.

"Bridgeport, Sept. 27.

"The late Storm which commenced on Thursday last continued with increasing violence until 11 o'clock on Saturday morning. The wind during the whole time blew a severe gale accompanied with rain from the N.E. and had so much increased the waters in the Sound that the tide, which in ordinary weather would have been full at 2 O'clock and 44 minutes, attained its greatest height at 12 o'clock 30 minutes, and was then near six feet above common flood tides; and had it not fortunately happened that the wind some hours before the tide was at full veered round to the N.W. it must have risen to an alarming height. The oldest inhabitants do not remember so high a tide by nearly one foot. The water through the whole length of Water Street was of sufficient depth for the largest long boat to pass loaded with passengers. Considerable damage has been sustained in the stores along the shore by the destruction of salt, grain and other bulky articles that could not speedily be removed.

From: "Norwich Courier", September 27, 1815.

"Norwich.

" . . . .

"The damage done in this town and neighborhood by the violence of the wind and the extraordinary rise of the tide, is great beyond precedent. Scarcely a store on the wharves has escaped injury - some of them have been entirely swept away - and goods to a considerable amount damaged or destroyed. The water on the wharves and the Lower Street was 4 feet higher than can be remembered on any former occasion . . . . The water beat over the wharf bridge with incredible force. Its depth there was at least 6 feet; and such was the fury from the action of the wind, that the market and a store adjoining were carried away. Immense numbers of trees, of every description, were levelled to the earth - As also fences in all direction.

"NEW LONDON.

"The effects of the gale within New London we understand were very much more severe than at this place. The wharves were ruined, and the shipping has suffered dreadfully. Many of the buildings on Beach Street are swept away - others unroofed - and fences and trees blown down in every direction."

"STONINGTON

"The tempest rages with extreme violence. A number of vessels bound to the eastward had put in here for a harbor, every one of which was driven on shore."

k. 2-3 September 1821. (Type "A") From: "Connecticut Herald," (New Haven), Tuesday, September 11.

"We were visited in the evening of the 3d inst. by a toronado almost unexampled in this latitude. The gale commenced at S.E. about 6 o'clock but was most violent from 8-10, the wind then varying from S.S.E. to S.W.--nearly all the vessels in the harbor were driven by the force of the storm, and are more or less damaged... Fortunately at the height of the gale, it was time of low water; otherwise,

damage to shipping, wharves, stores &c, must have been incalculable...The rafters and gable end of a brock store on the wharf...were blown down...part of the roof of Mr. Thomas Hunt's dwelling in Water St. was torn off... scarcely a street was exempted from fallen chimnies and fences. Several trees were upturned by the roots... the leaves of most of which remain are changed to a singular dark brown hue.

"Part of the first bridge on the pier was carried away by the driving of a sloop, who struck upon her stem.

"At Bridgeport, several buildings were blown down or unroofed..Almost all the vessels in port were driven ashore, but without much injury.

* * *

"New London, September 5.

"Severe Gale. --On Monday night last we experienced a severe gale from the South-East. It commenced about 7 in the evening, and lasted until midnight. The tide rose several feet above its ordinary level and some damage was done to our wharves and boats..."

From: "Black Rock, Seaport of Old Fairfield, Connecticut, 1699-1870."

"A tremendous gale of wind E & SE from 6 to 11 in the evening passed over this place--torn down many...trees... every vessel went ashore in this harbor--a sloop dismasted in the sound and the lighthouse laid flat. The hardest gale ever remembered.

"The leaves of the trees as in 1788 are turned brown.. small limbs of trees blew thirty rods--there was a continual roaring like thunder..."

1. 4 October 1841. (Type "B"). From: "Hartford Daily Courant," Tuesday, October 5.

"Severe Storm--We have been visited by a most remarkable storm--the like of which, so early in the season, on account of its severeity and continuance, is not remembered by our oldest inhabitants. On Saturday night it

commenced raining, the wind from the northeast, and continued without intermission, intermingled a part of the time with snow and accompanied by wind until sometime yesterday afternoon. During a part of Sunday night, the wind blew a perfect hurricane, and the rain came down in torrents...Many valuable fruit and ornamental trees have been prostrated or stripped of their limbs... as the storm undoubtedly extended along the coast, we may expect to hear of damage from that quarter."

m. 29-30 October 1866. (Type "B"). From: "Hartford Daily Courant," October 31.

"One of the hardest storms of the season prevailed on Monday and continued through yesterday. It was a regular southeaster--one of those violent storms that often haunt us at this season of the year--The wind prostrated the lines between New Haven and New York and at other places east and south. The steamer Granite State left New York at the usual hour on Monday and met with rough weather on the Sound..."

n. 8 September 1869. (Type "A"). From: "Norwich Morning Bulletin," September 12, 1869.

"Storm (at Mystic, Conn.) worst since 1815. Came at low water and the tide, though rising higher than it has for 2 or 3 years, did less damage than it otherwise would have done. Had it occurred at highwater, the bridge and a large part of Mystic would have been submerged. The tide rose at the rate of an inch a minute, walling up a foot high where it struck the spiles at the bridge."

o. 23 October 1878. (Type "A"). From: "The Daily Standard", Bridgeport, October 23,1878.

"A section of the fence...opposite the depot blew down this morning.

"A portion of the bulletin board corner High and Main Streets blew down this morning. Limbs were broken off the trees in all sections of the city.

"The storm last night and this morning drove a number of small boats ashore below the Naugatuck dock and their owners turned out and dragged them beyond reach of the waves...

"The sea held high carnival at Sea Side Park this morning, and a wilderness of rolling white caps and tempest of dashing spray bore witness to the disturbed mood of the waters, angered by the howling winds..."

From: "Greenwich Observer," October 24, 1878.

"....The storm yesterday was very severe and the shipping in our harbor was roughly tossed. The tide rose to a remarkable degree..."

From: "The Daily Standard," Bridgeport, October 24, 1878.

"New Haven, Oct. 23d,--The steamer John Bramhall, Captain Pollard, from this city, ashore on Little Cull Island, has gone to pieces in the gale."

p. 18 August 1879. (Type "B"). From: "Stamford Herald," (Weekly) August 20.

"---From a test made at Waterside the rainfall during the late storm was found to be 8 inches. On Monday from 7 a.m. to 7 p.m. a little over 4½ inches fell.

"A more soaking continuous and persistent rainstorm we have seldom experienced in August... corn has suffered under the infliction of so much rain and wind..."

q. 10 September 1889. (Type "A"). From: "The Greenwich News," Friday, September 13.

"The furious northeaster which has been raging along the Atlantic Coast for the past few days is one of the severest storms known in this vicinity for years, and one of the most destructive to property. Ever since Tuesday when the storm reached here from the Atlantic, it has blown a gale, mostly from the northeast, accompanied nearly all of the time by rain.

"The greatest force of the storm has been felt along the coastline...small craft along the shore have suffered severely...

"Greenwich has suffered comparatively little from the storm. A few tress have been blown down and the roads have been damaged more or less, but beyond this there was scarcely any damage done. On Tuesday there was a very high tide in the harbor and at one time part of the steamboat dock was under water...the only loss reported along the shore are one or two row boats."

* * *

"The schooner Annie Jacobs from New Haven...was beached on Mansuring Island during the storm Tuesday night."

From: "The Westerly Narragansett Weekly", September 19.

"The high surf last week drew crowds of sight-seers to Watch Hill from Westerly, Stonington and Mystic. It was a grand sight to see the big waves come rolling in, until apparently they were about to swamp the lamd. Not much damage was done except the destruction of the Peninsula house . . . . . "

r. 23-24 August 1893. (Type "A") From: "Stamford Advocate," August 24.

"One of the most severe storms of wind and rain ever experienced in this locality started last night and continued increasing in force until this forenoon. The evidence of its severeity were to be seen on every hand . . streets washed out and flooded, buildings damaged . . .

" . . . Every boat in the harbor was adrift . . . The tide rose higher than has ever known for some time. All the streets in the vicinity of Waterside were impassable, the water coming up over the meadows to the foot of Atlantic Street . . .

"The scene in the lower harbor at high tide this morning was a wild one . . . On the whole the craft in the lower harbor escaped well, much better probably than they would have done had a gale of equal force come in from the southwest."

s. 29 August 1893. (Type "A") From: "The Columbian Weekly Register," (New Haven), Thursday, August 31.

"Early this morning the wind blew 50 miles an hour, breaking all previous records . . . Late last night the barometer recorded 29.98, but it was only 29.38 early this morning . . .

"The waves swept in with terrible fury all along Savin Rock shore. They had full play at the docks made of logs and boards and stone. When the tide was high, about 8 o'clock, the water came up over Beach Street and threatened to enter the handsome shore cottages that front the harbor from Skeele's pavilion to O'Connell's hotel on the Rock . . . mud from the street was picked up by the spray and spattered on the windows. .

"The waves leaped into the air 20 or 30 feet at a time . . .

"The waves were . . . tumbling upon the street in front of the Surf House and were making their way into the ground floor of the hotel. The tide was at its height and soon after began to recede; with the falling of the tide the danger that threatened the house in being overflowed with a part of Long Island Sound subsided . . . The dock or wharf front of logs and boards was partially demolished. Mr. Cox's damage will be at least $500.00...

"But the storm's destructive power was felt in dead earnest at Stewart's pavilion and thereabouts in front of Sea View hotel. The Sound took one bite out of the solid earth in Front of Stewart's that was 75 feet long and 10 and 20 feet wide in some places...

"The wind was tearing over Savin Rock at a 60-mile gait."

From: "The Westerly Narragansett Weekly," August 31.

"Mystic.

"The storm did considerable damage. The schooner . . . broke loose from her bow fastening, drifted out lengthwise of the river, making a blockade. Telephone and telegraph lines are down. Numerous washouts occurred on railroad lines (in the area around Mystic)."

t. 9-10 September 1896. (Type "B") From: "Greenwich Graphic," September 25.

"Between five and six o'clock on Saturday night it rained and blew in a way that caused many people to be frightened. It was the most severe storm we have had this summer... From William St. to Putnam Ave. it was impassable after the storm.

The wind twisted the great trees and broke them as though they were pipe stems...The rain came down almost in torrents and on Greenwich Avenue the water flowed in the gutters like the stream from a large brook."

From: "The Day", Thursday, September 10.

"Groton.

"There is no doubt but what the wind could have blown harder than it did Wednesday night, but there is no one hereabouts but what is satisfied it blowed hard enough. The twigs and branches of the trees that strew the streets this morning was evidence of its destructive power. No greater damage outside of the breaking of trees was reported."

u. 16 September 1903. (Type "A") From: "The Bridgeport Daily Standard," September 17.

"Very strong winds and rain unroofed houses, felled or uprooted trees.

"...a casual survey of the damage along the waterfront shows that it will run into the thousands...

"At the Bridgeport Yacht Club in the Black Rock harbor there was damage galore, and but for the active work of the yachtsmen there would have been several fine yachts totally wrecked.

"Although the waves were very high the water did comparatively little damage...no water ever reached the roadway although everybody was completely drenched with the spray which rose in a long continuous, heavy white cloud the whole length of the sea wall."

From: "The Westerly Daily Sun", September 17.

"New Haven

"Southwest Connecticut came within the radius of the storm which swept up the Atlantic coast and the fury of the elements did greater damage than any disturbance of a like character in the month of September for a great many years. Trees were ripped up, telephone and telegraph wires were torn down . . . At many places small craft were dashed to pieces on the shore. Crop damage was severe."

From: "The Daily Advocate," Stamford, September 16.

"The storm which is raging all over this section struck Stamford with a vengeance at noon today and inside of an hour it had shaped itself into what old-timers say, is the swiftest easterly storm experienced for twenty years or more...

"On the east shore of Shippan, the storm was felt with great severity, and the same is true of Sound Beach where there are a number of summer cottages near the shore.

"The wind blew great guns...rain fell in veritable sheets. On exposed corners this was particularly noticeable, the pavements being under a constant wash of water... The wind came from the east and blew at from 75 to 80 miles an hour."

v. 15 September 1904. (Type "B"). From: "New Haven Evening Register," September 15.

"At one time early this morning, shortly after midnight the wind being then at the southwest, blew at the rate of 40 miles an hour....During the entire progress of the storm in New Haven 3.96 inches of rain fell... At Casey Beach, during the early part of the storm, the shore was heavily lashed by angry waves and for a time it seemed as though some of the lighter of the houses would be thrown from their foundations. Then the wind shifted and blew offshore and the water smoothened...Trees were uprooted and oyster beds damaged by the winds..."

w. 9-14 November 1904. (Type "B") From: "New Haven Evening Register," November 14.

"Here in New Haven the wind in yesterday's gale blew as high as 50 miles an hour. Many telephone and telegram wires were prostrated and there was some light wreckage about the harbor..."

x. 1 October 1920. (Type "A"). From: "The Daily Advocate," Stamford, October 1.

"The wind attained a velocity of 60 miles an hour, and it roared along the shorefront in an alarming manner, but did no great actual damage there. It veered from south by east, late in the afternoon to a more

southerly direction as the night wore on. Its greatest velocity was attained about midnight. That was sufficient to rock some houses on their foundations.

"Boats were torn from their moorings and trees were blown down."

* * *

"Norwalk, Oct. 1. --Last night's storm here was the worst in years, doing damage along the Sound shore. The tide reached a record height at 1 a.m., the water covering the roads and wrecking a number of cottages at Belle Island ...12 small boats were carried ashore and wrecked...and much damage done by the wind."

"New Haven, Oct. 1. Thousands of dollars of damage was done along the Sound shore last night by one of the worst storms in several years. Driven by a gale which exceeded 40 miles from the southeast and accompanied by a high tide. The waves rolled mountain high against the beach during the night, the tide reaching a record height about midnight. Many boats were washed ashore, cottages, piers and breakwaters being partially wrecked.

"At the Weather Bureau this morning it was stated that the wind reached a velocity of 42 miles at the height of the storm. A total rainfall yesterday and last night of 2.51 inches was recorded."

From: "The Day," October 1.

"New London

"The gale which swept the east last night and early this morning did a large amount of damage in Connecticut, principally to telephome, telegraph and trolley systems, caused the wrecking of 3 barges near this city and brought loss to rural districts through the destruction of late crops and fruit.

" . . . . . .

"New London was visited by an unusually severe wind and rain storm Thursday. The storm which began early in the day developed into a gale Thursday night,

the wind blowing with a velocity of about 80 miles an hour when it reached its height about midnight. The damage was considerable but not serious. Telephone and electric wires were blown down, limbs were ripped off trees and in one or two instances trees were uprooted. Shipping on the Sound was delayed."

y. 26 August 1924. (Type "B"). From: "Stamford Sentinel", August 27.

"Nothing like the devastation of felled wires, cables and poles in the eastern part of the state ever has been experienced by the telephone people..."

* * *

"New Haven, Conn. Aug. 27. ---With approximately 6,000 telephones out of commission in the territory east of Saybrook, a section of the state severely hit by a juvenile tornado late yesterday afternoon the Southern New England Telephone Company suffered more damage than ...in a great many years..."

z. 3 October 1929. (Type "A") From: "New Haven Journal-Courier," October 3.

"Damage which will probably total thousands of dollars was done yesterday along west shore in Milford by the lashing northeaster which swept northward from the Caribbean..its ferocity had been largely spent by the time it had reached the shores of Long Island Sound ...

"The largest damage reported from along the shore yesterday came from Silver Beach in Milford where the strong northeasterly and easterly gale created waves at the high tide hour this morning which tossed one cottage off its foundations...

"The water overflowed the trolley tracks and in some places covered the Milford shore road to a depth of two feet...the storm concentrated its fury on the Milford shore ...

"High tides came near flooding street car tracks where they pass close to the water's edge on the shore runs, it was said, but no delays were brought about by this cause.

"Official figures...for total rainfall...of 2.03 inches between 8 p.m. and 8 a.m. yesterday and precipitation for the 12 hours after 8 a.m. yesterday being 1.30 inch.

"The wind velocity at both 8 a.m. and 8 p.m. was 12 miles per hour atop the post office building, but reports had velocities of 25 miles an hour at Milford."

aa. 17-26 August 1933. (Type "A"). From: "Daily News-Graphic," (Greenwich) August 24.

"....HURRICANE'S EDGE WHIPS ACROSS TOWN.

"....the gale swept the madly rolling Sound. A total rainfall for the week of 3.71 inches was reported by the Water Company here, enough to flood a less undulating country."

From: "Bridgeport Post," August 24.

"GALE TEARS DOWN TREES...AS WAVES POUND SHORE:
DAMAGE ALONG COAST SET AT MILLIONS

"....the storm accompanied by a driving rain, whipped the Sound into a fury, halted shipping and threatened many shore cottages as it gathered velocity with the rising tide early this morning...

"....Little damage was reported...on Long Island Sound side of town although exceptionally high tides and turbulent seas were reported."

From: "The Sun", Westerly, R.I. August 24.

"Raging seas which for several days have threatened life and property at Watch Hill (Rhode Island) and other neighboring shore resorts reached their height last night, shortly before midnight and appeared to be on the wane.

"Made turbulent by a 60 mph gale which swept along the entire Washington County sea coast, giant combers crashed high against bulwarks and homes, seemingly centering their attack along Napatree Point, Watch Hill, where the only severe damage was reported.

"The waters swept high over the dunes at Napatree Point carrying thousands of tons of sand which were deposited along the Fort Road . . . . The storm subsided suddenly as the tide started outward."

"Stonington.

"The storm at Stonington has been severe the past few days and last night the high northeast wind changed to the southwest, bringing a hard rain, driven by the high wind . . . . All night long the waves lashed about the point and the sea combed all of the Stonington breakwaters . . . . The old dolphin has entirely disappeared and left a pile of rocks as a further menace to navigation."

bb. 9 September 1934. (Type "B") From: "Stamford Advocate," September 10.

".....Saturday night's furious storm did thousands of dollars' damages.

"The storm lashed at the New England coast, battering the Connecticut area with such fury that it left a trail of havoc, especially in Stamford and the surrounding towns... Trees were uprooted...cellars and streets flooded...."

From: "Daily News-Graphic,"(Greenwich) September 10.

"HIGHWAYS WASHED OUT BY HEAVY RAINFALL

"...an 85-mile-an-hour gale and nearly three inches of rain...Saturday night...felled trees and flooded cellars in all parts of town."

cc. 19 September 1936. (Type "B"). From: "Daily News-Graphic." (Greenwich,) September 19.

"HURRICANE DRIVEN GALES STREW GREENWICH WITH DEBRIS

"...trees uprooted...boats torn from their moorings in Greenwich Harbor, but scattered damage was not of record proportions...

"The gales, driving toward the Sound, came in the back-lash of the southern hurricane that roared up the Atlantic coast...

"Rainfall varied from two inches in the vicinity of Greenwich Water Company's Putnam lake filter plant to 2.76 in central Greenwich nearer Long Island Sound...

"Stamford police reported that Stamford was 'very lucky', no serious damage. Wires and branches were reported down in several places."

From: "Bridgeport Post," September 19.

"A tree-toppling gale...swept through Fairfield County last night and early today at a velocity of 45 miles an hour...wrecking damage of thousands of dollars. It was accompanied by torrential sheets of rain."

From: "Stamford Advocate," September 19.

"A howling wind, which drove before it a heavy rain, swept over Stamford last night and early today, disrupting telephone and electrical service in the town and city...

"...the rainfall, recorded at two inches, continued at intervals...

"...no damage to shipping...Several boats dragged from their moorings."

dd. New London 21 September 1938. (Type "A") From: "The Day", , September 22.

"The gale striking the city about 3:00 p.m. yesterday, jolted the city into a twisted mass of wreck and ruin, tearing roofs off buildings, uprooting trees, caving in brick walls and blowing out windows. There are 4 known dead, 5 missing and at least 75 injured.

"Never before has New London seen such a terrific catastrophe. Streets piled with debris, fires raging in a gale estimated at 90 miles an hour...

"Meanwhile, an unprecedented tide accompanying the hurricane drove the Thames River over its banks. The raging waters climbed 4 to 6 feet above the roadbed of the New York, New Haven and Hartford railroad tracks, flooding the Union Station...

"The howling wind, was estimated to have velocity as high as 120 miles an hour at Fishers Island.

"The pounding wind and tide made a shambles of the Ocean Beach section. The boardwalk and 50 or more summer cottages bordering it, together with cottages in the Neptune Park section were demolished.

"At least one death and an unestimated number of injuries were revealed in Groton Borough this morning, along with property damage that runs into thousands and thousands of dollars...

"Shennecossett beach buildings were picked up and flung back onto Beach Pond road. The beach club site is marked by a few piles.

"Bluff Point and Jupiter Point was described today as barren promontories, with practically all cottages there washed into the Poquonoc River and Bakers Cove. Groton Long Point and all other places along the waterfront suffered similar disasters. Property damage in the wealthy Eastern Point section was enormous.

"The rain was driven by a southeast wind. . . . Rainfall of 4.08 inches was recorded from 4:30 o'clock yesterday afternoon to 7:30 o'clock this morning, and it was this tremendous volume of water that gave the final 'kick' to streams which already had mounted high.

"This rainfall reading was made at Lake Konomoc, the city's main reservoir at Waterford, which raced upward eight and one-quarter (8¼) inches during yesterday to go 12 inches above spillway level. The water was gushing in a sweeping fall 6 inches above emergency flash-boards. The City Engineer reported that the rainfall at the Reservoir since Saturday was 10.01 inches.

"Damages due to the hurricane and the fire which started during the hurricane were estimated at $4,000,000.

"NORWICH

"Norwich where the Thames River starts, is on tidewater. The Yantic and Shetucket Rivers meet to form the Thames. All Rivers were up to their banks when the hurricane hit. Three hours later the tide backed the water up 11 feet in one hour. Most river towns know when their water is rising 6 inches to the hour and the people can do something about belongings. When water rises 11 feet in one hour as in Norwich everyone just runs for high ground.

ee. 14 September 1944 (Type "A"). From: "The Day", New London, September 15, 1944.

"The tropical hurricane, which had been sweeping up the Atlantic from the Bahamas, struck this section last night to exact a toll of 2 dead and 2 injured and property damage as yet unknown but estimated to be very heavy. It halted rail, bus and automobile traffic, uprooted trees and poles, leveled beach pavilions, wrought great loss at shore resorts, left practically the entire city without light or power, sank many boats and tossed others up onto the shore in this city and at Niantic, principally washed out railroad tracks, greatly interrupted telephone and wire service.

"Not nearly as violent or as far reaching in its effects as the great hurricane of September 21, 1938, the storm made up of a wind that attained an official velocity of 95 miles an hour, a torrential rain and high seas that assumed in some areas, the aspects of a tidal wave . . . . .

"The local hurricane damage was particularly severe along the lower water front and Osprey, Guthrie, Pequot Point, and Rogers beaches were completely destroyed and the entire south section of the concrete walk at Neptune park was carried away and at least 4 of the cottages on the walk were undermined.

"The tremendous tide and angry surf completely leveled the bathing pavilions at Osprey and Pequot Point beaches, all the cabanas and lockers at Guthrie beach were carried away, and at Rogers beach, the bathhouses were damaged beyond repair, and the raft was dragged from its anchorage and hurled bottom-side up onto the beach.

"When the tide was at its height and the storm at its peak the sea surged completely over the tops of the pavilions at Osprey and Pequot Point beaches and over the wall into Pequot Avenue. At Neptune Park the waves started battering the boardwalk or sea wall early in the evening and eventually cascaded over it to pound at the houses bordering it.

"The Braunstein-Freres plant which was partially demolished in the hurricane of 1938, took another beating last night and the damage will run into thousands of dollars, according to the Manager. The tidal waters and rain poured into this building to flood it to a depth of about 9 inches. In the front or mail building there was 4 inches of water . . . .

"The storm caused little damage above the Thames River Highway bridge ....

"The tide swept up over the walls at the ship yard and flooded the yard and several buildings . . . .

"The old road to Norwich - Williams Street extension through Quaker Hill - was blocked late in the evening when the water of Smith Cove backed up over the road. It was 2½ to 3 feet deep where Hunt's Brook enters the Cove, and impassable. At the bend of the road, near the Quaker Hill firehouse, the waters of the cove also backed up, partly flooding the lower floor of the store and Quaker Hill Post Office, . . . but in the basement the water was over the top of the furnace, water pump, etc.

"In most of the cases of flooding of roads along various coves of the Thames River, the high water came well after the time of high tide, in the evening. The water backed up the most, it appeared, about 11:00 o'clock while high tide in New London, was supposed to be at 8:27 p.m., war time, last night.

"Niantic's shoreline again received the full blast of last night's hurricane but the damage was not as severe as in 1938. Niantic beach suffered damage estimated at between $4,000 and $6,000 during the hurricane, according to an estimate of its owner.

"At Crescent beach the tide came over the beach onto the road by the Elms Hotel and the cottages on White beach in front of the fresh water pond were surrounded by water, but little damage was done.

"A total of 4.02 inches of rain - more than half an inch an hour - fell in New Haven from 6:00 p.m. yesterday until the hurricane abated early today, and the figure for Hartford was 4.05 inches.

"One fact which perhaps prevented greater damage was that the wind blew against the tide which was high at the height of the storm, holding back the surging waters of Long Island Sound to a great extent."

ff. 31 August 1954. (Type "A") From: "The Day", New London, August 31, 1954.

"A multi-million dollar devastation along the southeastern Connecticut shore line. The wind damage was nowhere near as great as in the 1938 hurricane. Sea water rose higher, at least at several points in this harbor where buildings showed comparable tide marks.

"The fury of the storm struck at about 10:00 a.m., almost 2 hours before full high tide. High tide was at 11:55 a.m. Had the heart of the storm struck then, damage undoubtedly would have been worse. As it was the water rose an estimated 6 feet above the normal high water mark, flooding shore areas.

"Damages may run to $5,000,000 between the Connecticut and Pawcatuck rivers and up the Thames to Norwich. Twenty to 25 cottages were wrecked at Point O'Woods, the most concentrated disaster, closely followed by the Stonington, Lord's Point, and Jupiter Point home and cottage losses.

"A survey indicates that 2,488 cottages on the shoreline between East Haven and the Rhode Island line were either destroyed or damaged. The survey also indicated that 1,889 boats of all kinds and 129 automobiles were either ruined or damaged. Approximately 75,000 bushels of apples are on the ground, representing a loss of about $150,000. The County Agent said damage to apple and peach trees themselves, many of which were blown down, may hit $25,000.

"NOANK.

"The high tide, coming about an hour after the climax of the gale, pushed water about 7 feet above normal and flooded homes and wells in low-lying sections of town. Automobiles left near the shore were under water for hours.

"OCEAN BEACH.

"Damage estimated at $36,000 to concessionaires amusements. At the height of the storm there was about 3 feet of water in the inclosure. Most of the damage was from water but there was some wind damage.

"PAWCATUCK.

"Storm damage estimated to be $100,000 . . .

"Higgins Drug store in the heart of the business district where an 8 foot high cellar . . . was completely flooded and water entered the main floor of the store. In other buildings in the business section, water rose to about 2 feet on the ground floors.

"MYSTIC.

"The main streets of Mystic were under 4 feet of water during the storm.

gg. 11 September 1954. (Type "B") From: "The Day", New London, September 13.

"She (hurricane) stabbed the area for 8 hours Saturday ...

"She deposited more than 6 inches of rain - a record - and caused floods in areas where brooks overflowed or the catch basins couldn't contain the water.

"She might have done more damage, but she spent most of her fury in this area at a time when the tide was at low ebb.

"The Groton filtration plant in Poquonoc Bridge reported a fall of 6.15 inches from midnight Friday to 3:00 p.m. Saturday, a record for a 14 hour period...

"The wind was reported at 75 miles an hour."

A-4. HURRICANE TRACKS

The tracks of four notable hurricanes causing tidal flooding and serious damages along the Connecticut coast, namely, those of September 1815, September 1938, September 1944, and August 1954 are shown on Plate A-1. The path of Hurricane "Diane" (1955), a storm which brought record rainfall to many areas in southern New England, is also shown on the plate.

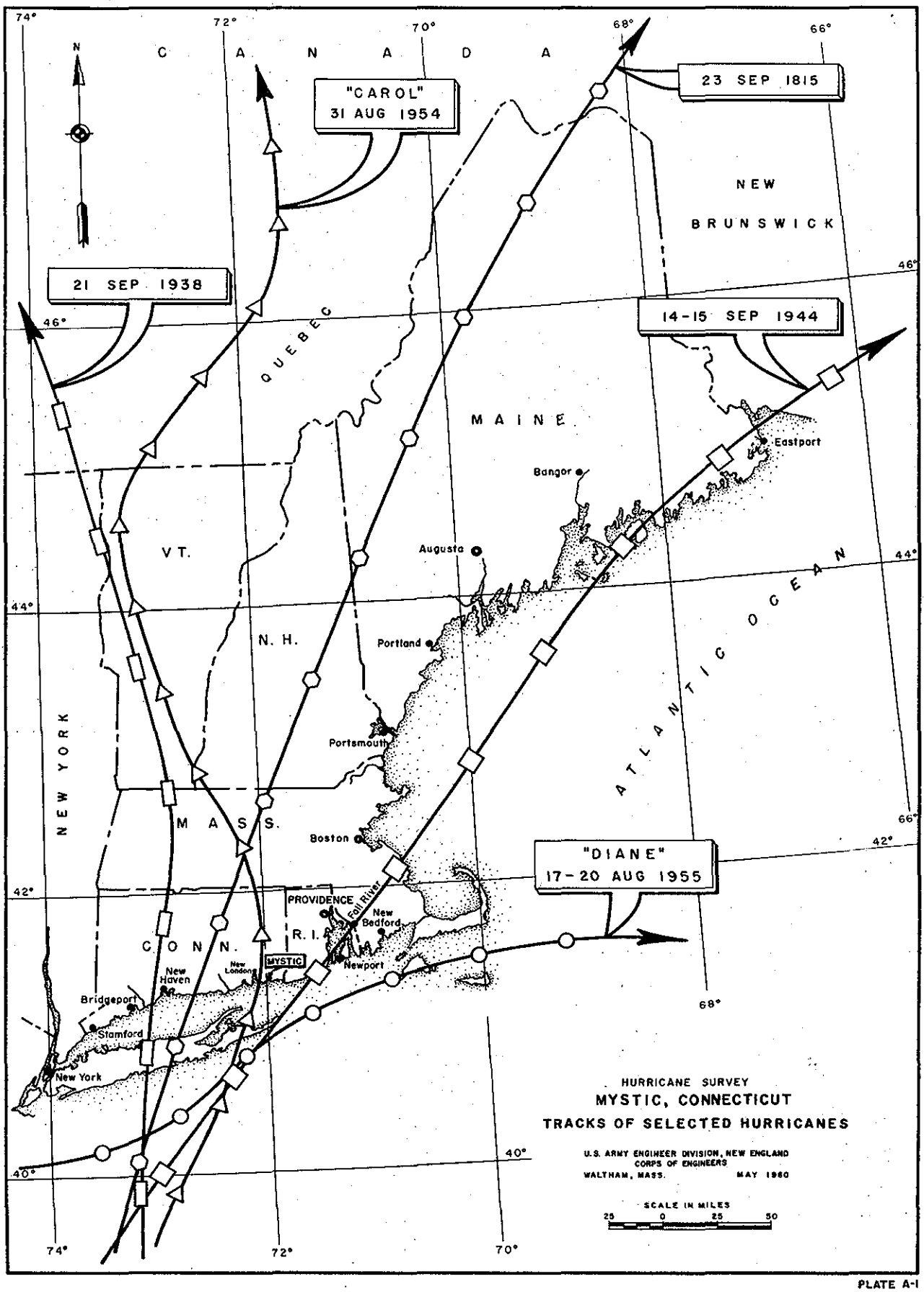

"CAROL"
31 AUG 1954
23 SEP 1815
21 SEP 1938
14-15 SEP 1944
"DIANE"
17-20 AUG 1955
CANADA
NEW BRUNSWICK
QUEBEC
MAINE
VT.
N. H.
MASS.
CONN.
R.I.
NEW YORK
ATLANTIC OCEAN
Eastport
Bangor
Augusta
Portland
Portsmouth
Boston
PROVIDENCE
Fall River
New Bedford
Newport
MYSTIC
New London
New Haven
Bridgeport
Stamford
New York
74°
72°
70°
68°
66°
46°
44°
42°
40°
HURRICANE SURVEY
MYSTIC, CONNECTICUT
TRACKS OF SELECTED HURRICANES
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960
SCALE IN MILES
25 0 25 50

PLATE A-I

APPENDIX B

HYDROLOGY AND HYDRAULICS

APPENDIX B

HYDROLOGY AND HYDRAULICS

INTRODUCTION

B-1. This appendix presents data to supplement the sections of the main report relating to the subjects of hydrology and hydraulics. It includes a summary of temperature and precipitation data to amplify the section of the report on "Climatology", a summary of streamflow, and data on hurricane wind velocities, rainfall values, and barometric pressures to augment report material on the history and frequency of hurricanes. Computations of runup and ponding, determination of tidal flood levels and design storm tide, detailed analyses of wave height, runup, overtopping, and current velocities are also included in this Appendix.

HYDROLOGY

B-2. TEMPERATURE AND PRECIPITATION

Significant temperature and precipitation data taken from the United States Weather Bureau Station at New London, Connecticut approximately 10 miles to the west of Mystic are considered typical of the Mystic area. The monthly mean temperatures are based on the period of record from 1871 to 1954, while the maximum and minimum temperatures are based on the period 1885 to 1954. The monthly mean, maximum and minimum precipitation is based on an 84-year record (1871-1954). Tables B-1 and B-2 summarize the temperature and precipitation records.

TABLE B-1

MONTHLY TEMPERATURE

NEW LONDON, CONNECTICUT

Month	Degrees Fahrenheit Mean	Maximum	Minimum
Jan.	29.8	67	- 7
Feb.	29.8	68	- 17(1)
Mar.	37.4	84	3
Apr.	46.9	91	13
May	57.4	93	31
June	66.2	97	38
July	71.7	99	44
Aug.	70.3	100(2)	44
Sept.	64.4	95	35
Oct.	54.3	87	24
Nov.	43.4	77	9
Dec.	33.0	67	- 12
Annual	50.4		

(1) 9 Feb. 1934
(2) 26 Aug. 1948

TABLE B-2

MONTHLY PRECIPITATION

NEW LONDON, CONNECTICUT

Month	Inches Mean	Maximum	Minimum
Jan.	4.04	8.61	0.50
Feb.	3.62	11.98	.43
Mar.	4.20	10.96	.35
Apr.	3.76	10.85	.64
May	3.49	9.03	.54
June	3.09	7.71	.01(1)
July	3.53	7.13	.44
Aug.	4.39	16.44(2)	.48
Sept.	3.41	11.21	.33
Oct.	3.52	8.47	.20
Nov.	3.83	9.40	.32
Dec.	3.77	10.67	.73
Annual	44.61	60.62(3)	30.05(4)

(1) 1949
(2) 1874
(3) 1919
(4) 1896

B-3. RUNOFF AND STREAMFLOW

There are no streamflow records for the Mystic River Basin. There are four U.S.Geological Survey stream gaging stations, located within 20 to 30 miles from Mystic, Connecticut, considered representative of the discharge of the Mystic River Basin shown in Table B-3.

TABLE B-3

STREAMFLOW DATA

AT U.S.G.S. GAGING STATIONS
NEAR MYSTIC, CONNECTICUT

Rivers and Location of Gaging Stations	Drainage Area (sq.mi.)	Period of Record (years)	Peak Discharge (cfs)	Peak Discharge (cfm)(1)	Date
Yantic River Yantic, Conn.	88.6	25	13,500	152.5	21 Sept.1938
East Branch Eightmile River near North Lyme, Conn.	22.0	18	2,950	134	21 Sept.1938
West Branch Eightmile River North Plain, Conn.	18.6	18	2,350	126	15 Oct.1955
Menunketesuck River near Clinton, Conn.	11.6	14	870	75	12 Nov.1947

(1) cubic feet per second per square mile

B-4. DRAINAGE AREA

The total drainage area of the Mystic River and Harbor above the protective barrier at Sixpenny Island crossing is 29.5 square miles. This includes 588 acres of ponding area above the barrier (see Plate B-1). Drainage area of the Mystic River and Pequotsepos Brook at the New York, New Haven and Hartford Railroad bridge where they empty into the harbor are 26.4 square miles and 2.2 square miles, respectively.

B-5. HURRICANE RAINFALL

Among the greatest rainfalls associated with hurricanes in New England are those recorded for "Connie" and "Diane" in August 1955. Hurricane "Connie", 11-15 August, caused rainfall varying from about four to six inches

over southern New England and ended a period of drought. A week later, 17-20 August, Hurricane "Diane" brought rainfall of 16 to 20 inches over Connecticut and Massachusetts. These hurricanes caused a total fall of 7.95 inches at Groton, and 5.8 inches at New London, Connecticut, 8-10 miles west of Mystic.

Excessive rainfall also was associated with the September 1938 hurricane. The maximum precipitation for the September 1938 storm was concentrated over Portland (Buck), Connecticut, about one mile north of Middletown, where a total of 17 inches was recorded for the period 17-21 September. However, at Kingston, Rhode Island, 25 miles northeast of Mystic, the total was 2.8 inches, and at New Haven, Connecticut, 50 miles west of Mystic, the total was 11.6 inches.

The recorded rainfall at five U. S. Weather Bureau stations near Mystic in a number of recent hurricanes is tabulated in Table B-4, and may be considered indicative of amounts that can occur in the Mystic area.

B-6. HURRICANE WINDS

The most reliable data on experienced hurricane wind velocities in New England begin with the September 1938 hurricane. The maximum velocity in New England during this storm was a recorded gust of 186 m.p.h. at the Blue Hill Observatory in Milton, Massachusetts where a sustained 5-minute wind of 121 m.p.h. was also recorded. At other locations in southern New England, sustained 5-minute velocities ranging from 38 to 87 m.p.h. were experienced.

Sustained 5-minute velocities of from 33 to 85 m.p.h. were recorded at a number of locations along the New England coast during the hurricane of 14 September 1944.

In southern New England, during Hurricane "Carol" (31 August 1954), gusts of 125 and 135 m.p.h. were experienced at Blue Hill Observatory, Milton, Massachusetts and Block Island, Rhode Island, respectively. Sustained 1-minute velocities ranging from 38 to 98 m.p.h. were registered.

Recorded wind velocities at locations in southern New England for the three great hurricanes of 1938, 1944, and 1954, are given in Table B-5.

B-7. HURRICANE BAROMETRIC PRESSURES

The center, or "eye", of the 1938 hurricane entered Connecticut about 5 miles west of New Haven or about 55 miles west of Mystic at about 3:30 P.M., E.S.T., on 21 September and then proceeded northwesterly at a rate of 50 to 60 m.p.h. The lowest pressure registered during the passage of this storm was 28.04 inches at Hartford, Connecticut.

TABLE B-4

HURRICANE AND OTHER STORM RAINFALL

VICINITY OF MYSTIC, CONNECTICUT

ACCUMULATED RAINFALL IN INCHES

Hurricane or Other Storm	Westbrook, Conn. Max.(1) 24-hr.	Total	New London, Conn. Max.(1) 24-hr.	Total	Groton, Conn. Max.(1) 24-hr.	Total	Kingston, R.I. Max. 24-hr.	Total	New Haven, Conn. Max. 24-hr.	Total
Sept. 1938	-	-	-	-	-	-	1.3	2.8	6.4	11.6
Sept. 1944	2.8	6.2	3.4	7.1	-	-	2.4	4.4	4.0	8.5
Aug. 1954 (Carol)	4.4	4.4	4.5	5.0	3.4	3.5	2.9(1)	2.9	2.75	2.75
Sept. 1954 (Edna)	5.6	5.6	4.0	5.3	6.2	6.2	5.5(1)	5.5	5.55	5.55
Aug. 1955 (Connie)	4.3	7.3	2.0	4.0	5.1	5.6	5.3(1)	5.7	3.2	3.6
Aug. 1955 (Diane)	1.4	2.2	1.8	1.8	1.2	2.3	2.2(1)	3.2	3.2	4.3
Oct. 1955	-	5.1	-	-	2.3	4.3	3.1(1)	4.65	3.8	5.9

(1) Non-recording station - values based on daily readings.

In the hurricane of 14 September 1944, the "eye" of the storm passed inland between Charlestown and Point Judith, Rhode Island, (20 miles east of Mystic) at 10:20 P.M., E.S.T. It then continued in a northeasterly direction, veering out to sea at Boston, Massachusetts. The minimum recorded barometric pressure in southern New England during this storm was 28.31 inches at Point Judith, Rhode Island.

The center of Hurricane "Carol" (31 August 1954) crossed the south shore of Connecticut in the vicinity of New London (10 miles west of Mystic) at about 10:30 A.M., E.S.T., and then followed a general northwesterly path across New England. The minimum barometric pressures in New England upon the occasion of this hurricane were 28.20 inches at Storrs, Connecticut, (35 miles northwest of Mystic) and 28.26 inches at New London.

The minimum pressures recorded at a number of New England locations during these three great hurricanes of the past 20 years are given in Table B-6.

B-8. DESIGN RUNOFF

The design flood for Sixpenny Island Crossing (drainage area = 29.5 sq. mi.) has been based on available data for the Moshassuck River at Providence, Rhode Island (drainage area = 23.8 square miles) for which the design runoff was derived from rainfall in the 21 September 1938 hurricane. The Moshassuck River design hydrograph was based on transposing the center of the 1938 rainfall (9.5 inches in 24 hours) over the basin and determining discharge by synthetic unit graph analysis. The similarity of the Moshassuck and Mystic River basins in size, topography, and development of the areas makes possible direct determination of the Mystic Harbor design hydrograph by a drainage area relationship (see Plate B-2) which gives a peak discharge of 4,560 c.f.s., or 155 c.f.s. per square mile.

HYDRAULICS

B-9. HURRICANE OR STORM-TIDE FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations in the Groton-Stonington area during Hurricane "Carol" (1954) were obtained in the course of damage-survey work in the field for the southern New England coastline. The elevation of these flood levels, referred to mean sea level, were then determined by a field level party. This information was supplemented by material on high water levels collected by this office after the September 1938 hurricane. Based on this information, profiles have been prepared of the 1938 and August 1954 tidal-flood elevations between Willets Point, New York at the western end of Long Island Sound, and Wareham, Massachusetts at the eastern end of Buzzards Bay. A map and profile for the coastline between the Connecticut River on the west and the Connecticut state line on the east have been prepared. (See Plates B-3 and B-4). At approximately mile 102+60, Mystic Harbor, a general level of 10.4 feet, m.s.l. in 1938 and 8.8 feet, m.s.l. in 1954 are indicated.

TABLE 5

WIND VELOCITIES

HURRICANES OF 1938, 1944 AND 1954 IN NEW ENGLAND

Location	Velocity in Miles Per Hour: Sustained 5-Min.	Sustained 1-Min.	Maximum Gust	Direction
	Hurricane of 21 September 1938			
Hartford, Conn.	46	-	59	NE
New Haven, Conn.	38	-	46	NE
Providence, R. I.	87	95	125(est)	SW
Block Island, R. I.	82	-	91	SE
Milton, Mass. (Blue Hill Observatory)	121	-	186	S
	Hurricane of 14 September 1944			
New Haven, Conn.	33	38	65	N to NE
Hartford, Conn.	50	62	109(est)	N
Block Island, R. I.	82	88	100+	SE
Chatham, Mass.	-	85	100(est)	-
Point Judith, R. I.	85(est)	90(est)	-	SSE
Milton, Mass. (Blue Hill Observatory)	67	77	-	-
	Hurricane of 31 August 1954, "Carol"			
Bridgeport, Conn.	-	-	60	-
New Haven, Conn.	-	38	65	N
Hartford, Conn.	-	56	64	NE
Block Island, R. I.	-	98	135	SE
Milton, Mass. (Blue Hill Observatory)	-	93	125	SE

TABLE B-6

MINIMUM BAROMETRIC PRESSURES

HURRICANES OF 1938, 1944 AND 1954 IN NEW ENGLAND

Location	Time (EST)	Barometer (inches)
	Hurricane of 21 September 1938	
Hartford, Conn.	4:17 P.M.	28.04
New Haven, Conn.	3:30 P.M.	28.11
Block Island, R. I.	3:05 P.M.	28.66
Milton, Mass. (Blue Hill Observatory)	- -	29.01
	Hurricane of 14 September 1944	
Hartford, Conn.	9:50 P.M.	28.94
New Haven, Conn.	8:50 P.M.	28.86
Block Island, R. I.	10:09 P.M.	28.34
Point Judith, R. I.	10:20 P.M.	28.31
Westerly, R. I.	9:40 P.M.	28.43
Milton, Mass. (Blue Hill Observatory)	- -	28.62
	Hurricane of 31 August 1954	
New London, Conn.	10:00 A.M.	28.26
New Haven, Conn.	9:10 A.M.	28.77
Storrs, Conn.	11:00 A.M.	28.20
Block Island, R. I.	10:00 A.M.	28.5
Milton, Mass. (Blue Hill Observatory)	- -	29.9

Tidal elevation-frequency data shown in Table B-7 for New London, Connecticut were used as a guide in the preparation of a tidal elevation-frequency curve for Mystic Harbor (see Plate B-5). The New London location is a good index for Mystic Harbor, having an identical mean tide range of 2.6 feet, high water elevations in 1938 and 1954 of 9.7 and 8.9 feet, m.s.l., respectively, 0.7 foot lower and 0.1 foot higher than at Mystic Harbor. The New London frequency curve represents a composite curve based on the 142-year period 1815-1956 that influences the upper portion of the curve and the 18.5-year period July 1938-December 1956 for which there is a continuous tide gage record that determines the lower portion of the curve. High water information along the shores of Long Island Sound and Narragansett Bay indicates that the highest tidal-flood levels in the 142-year period occurred during the hurricanes of 1938 and 1954 ("Carol").

B-10. PONDING

The volume of runoff contributing to the pool behind the barrier of the Mystic Harbor Sixpenny Island crossing with design runoff (see Plate B-2) is 2,400 acre-feet during the 6 hours of navigation gate closure in a design hurricane (see Plate B-6). This assumes the rare combination of design runoff occurring coincident with a design surge plus a high spring tide. The maximum ponding, however, would be to elevation 3.4 feet, m.s.l., 0.4 foot below the stage where damage begins. Gate closure was assumed at zero feet, m.s.l., on the flood tide, and opening of the gates to discharge the stored water was on the ebb tide at the time landward and seaward water levels were equal. Ponding in the event of recurrence of 1938, 1944, and 1954 hurricanes would be less than for the above conditions because runoff from rainfall coincident with the respective storm tides is small in comparison to the design runoff. Navigation gates would be closed in these three storms somewhat longer than 6 hours because ponding is less and gate closure would be on the ebb tide when landward and seaward water levels are equal.

The peak levels of ponding in Mystic Harbor from design runoff have been determined from the area-capacity curves shown on Plate B-7. The curves are based on U.S. Geological Survey maps.

B-11. DESIGN STORM-TIDE DERIVATION

A memorandum dated 17 May 1957 to the Beach Erosion Board from the Department of Oceanography of the Agricultural and Mechanical College of Texas, under contract to make surge calculations of Long Island Sound, is the basis for design surge for Mystic Harbor. The evaluation of design storm surges for Long Island Sound was made by verification of analytical computations with information observed on high water levels in the Sound during the 1938 hurricane. The wind and barometric pressure patterns utilized in the 1938 hurricane problem were taken from U. S. Weather Bureau Memorandum HUR 7-8, dated 1 June 1956. Storm speeds of the design hurricane were for 30 knots and 40 knots, with the latter condition most critical in the eastern and western portions of the Sound, and the 30 knot speed producing higher surges in between the eastern and western

TABLE B-7

TIDAL ELEVATIONS VS. FREQUENCY DATA

HURRICANES AND SEVERE STORMS

NEW LONDON, CONNECTICUT

Hurricane or Storm	Maximum Tidal Elevation (feet, m.s.l.)		Percent Chance of Occurrence in any one yr.(1) (1815-1956)	(July 1938-Dec. 1956)
Hurricane, 21 Sept. 1938	9.7	(2)	0.35	2.7
Hurricane, 31 Aug. 1954	8.9	(2)	1.06	8.1
Storm, 25 Nov. 1950	6.7	(3)		13.5
Hurricane, 14 Sept. 1944	6.2	(4)		18.9
Storm, 7 Nov. 1953	5.9	(3)		24.3
Storm, 12 Nov. 1947	4.9	(3)		29.7
Storm, 3 Mar. 1942	4.7	(3)		35.1
Storm, 30 Nov. 1944	4.6	(3)		40.5
Storm, 16 Mar. 1956	4.5	(3)		45.9
Storm, 2 Dec. 1942	4.4	(3)		51.4
Storm, 3 Nov. 1951	4.3	(3)		56.8
Storm, 6 Mar. 1943	4.2	(3)		62.2
Storm, 12 Dec. 1944	4.2	(3)		67.6
Storm, 22 Nov. 1945	4.2	(4)		73.0
Storm, 16 Oct. 1955	4.2	(3)		78.4
Storm, 31 Oct. 1947	4.1	(3)		83.8
Storm, 21 Nov. 1944	4.0	(3)		89.2
Storm, 15 Oct. 1954	4.0	(3)		94.6
Storm, 27 Nov. 1940	3.8	(3)		100.0

(1) Calculated plotting position:-

$$P = \frac{100(M-0.5)}{Y}$$ where

P= percent chance of occurrence in one year.
M= number of the event.
Y= number of years of record.

(2) Based on high water marks at New London, Conn.
(3) Based on U.S.C.&G.S. recording tide gage reading at New London Harbor, New London, Conn.
(4) Estimated by U.S.C.&G.S.

portions. The design hurricane was considered to move north so that the region of maximum winds was directed into the southern sound entrance between Block Island and Montauk Point. The design hurricane corresponds to a transposition of the 1944 hurricane, which was especially severe off Cape Hatteras with wind field and pressures as specified in U.S. Weather Bureau Memoranda Nos. HUR 7-13 and 7-21, dated 1 August 1956 and 23 January 1957, to the Chief of Engineers and is about equivalent to a Standard Project Hurricane at the mouth of Long Island Sound. In Mystic Harbor, to allow for differences between observed and computed surges in the 1938 hurricane, the computed design surge for the 40 knot storm was modified by the ratio of the observed 1938 surge to the computed 1938 surge. To determine a design still water level, the design surge was added to a high spring tide equivalent to the spring tide predicted for 24 and 25 September 1957, as shown on Plate B-4. The results for Mystic Harbor are summarized as follows:

Design storm surge (40 knot speed), feet	12.5
High spring tide, feet, m.s.l.	2.4
Design still water level, feet, m.s.l.	14.9

The ratio of design surge to the 1938 surge is approximately 1.3.

B-12. WAVE HEIGHTS AND RUNUP

Design wave heights and wave runup have been derived for the proposed barrier, dikes and walls in Mystic Harbor. They were determined for conditions of an 85 m.p.h. wind from the southeast, coincident with the design peak surge of 12.5 feet and a spring tide of 2.4 feet, m.s.l. Significant wave height of 5.4 feet and period of 5.0 seconds at the Noank, Connecticut shore has been determined for the fetch of 3.3 statute miles (2.9 nautical miles) between East Point on Fishers Island and Noank. To account for the effect of wave refraction, considering the angle between wind direction and the Sixpenny Island Crossing, and the diffraction effect between the mainland and Mason Island, a value of K=0.6 reduces the wave height to 3.3 feet with an approximate period of 3.8 seconds. Similarly, these significant values of wave height and period are applicable to the barrier east of Mason Island.

Runup, the vertical rise of water above the still water level of 14.9 feet, m.s.l., in the design hurricane, ranges between 2.5 and 5.0 feet, based on the significant wave data. The maximum runup occurs at the navigation gate.

B-13. OVERTOPPING

The amount of overtopping is important not only in the design of a safe structure but also from the standpoint of flooding that may be caused by the ponding of the overtopping water. Rates of overtopping were determined for a peak still water level of 14.9 feet, m.s.l., and for several lower elevations in the design hurricane. The significant

wave height of 3.3 feet and wave period of 3.8 seconds in a design hurricane were used in all computations. The duration of overtopping is estimated from the tide graph for the design hurricane shown on Plate B-6. Overtopping data were obtained by interpolation and extrapolation of the curves in Beach Erosion Technical Manual No. 64 which relate the rate of overtopping in cubic feet per second per foot of length to the crest elevation above still water, with wave heights as a third variable. These curves were derived from data gathered in experimental wave tank tests made at the Waterways Experiment Station for the Beach Erosion Board and therefore are for uniform waves mechanically generated. To stimulate the actual wave train in nature, consideration was given to overtopping associated with each wave height in the wave spectrum. These were weighted according to the relative frequency of occurrence of the particular height (as given by statistical analysis of wave height frequency) and then summated in order to get the final value of overtopping associated with a wave train of given significant height. The volume of overtopping has been determined as 200 acre-feet based on an average rate of 1,400 c.f.s. for an hour and three quarters. It is estimated that overtopping begins at an average elevation of 8 feet, m.s.l. Assuming the navigation gates are closed on flood tide at zero feet, m.s.l., the volume of overtopping would cause the pool to rise 0.4 feet.

A key to the relative importance of overtopping of proposed protective structures in a design hurricane is the runup of 2.5 to 5.0 feet. The top of wave runup in a design hurricane will range from 0.9 to 3.4 feet over the top of protective works; the higher runup taking place at the gate section. Considerably less overtopping is indicated in the event of recurring 1938 and 1954 hurricanes because the peak still water levels of 10.4 and 8.8 feet, m.s.l. are 4.5 feet and 6.1 feet, respectively, below the level of the design hurricane. (See Plate B-6). In any event, overtopping is of relatively minor consequence because of the large storage capacity in the harbor area.

B-14. CURRENT VELOCITIES IN NAVIGATION CHANNEL

The width and sill elevations of the gated navigation opening determine the current velocities through the channel opening. Computations of velocities in the navigation opening were based on routing calculations predicated on the storage capacity in the harbor and the formula $Q=CA\sqrt{2gh}$, where "h" equals the difference between the water surface elevations on the Fishers Island side and the harbor side of the barrier, and "C" is a coefficient of discharge assumed to equal 0.6. This formula does not evaluate all the variable losses from contraction, expansion, friction, wind, and other indeterminate factors, but it is believed that the adopted coefficient provides reasonable results.

It has been determined by the routing calculations that the average velocity in the cross section of the opening is 2.1 knots at both the flood and ebb tides with the occurrence of an average spring range of tide and 10 percent less with a mean tide range. It is estimated that the maximum current in the cross section would be at the center of the opening, near the surface, and would be approximately 30 percent greater than the 2.1 knot average.

The navigation opening has the effect of causing a lag in the tidal cycle of about 30 minutes between the Fishers Island Sound side of the barrier and the harbor side; but no change in the tide range occurs.

The existing ungated opening at the New York, New Haven and Hartford Railroad causeway has velocities of less than 1.3 knots with the occurrence of spring tides.

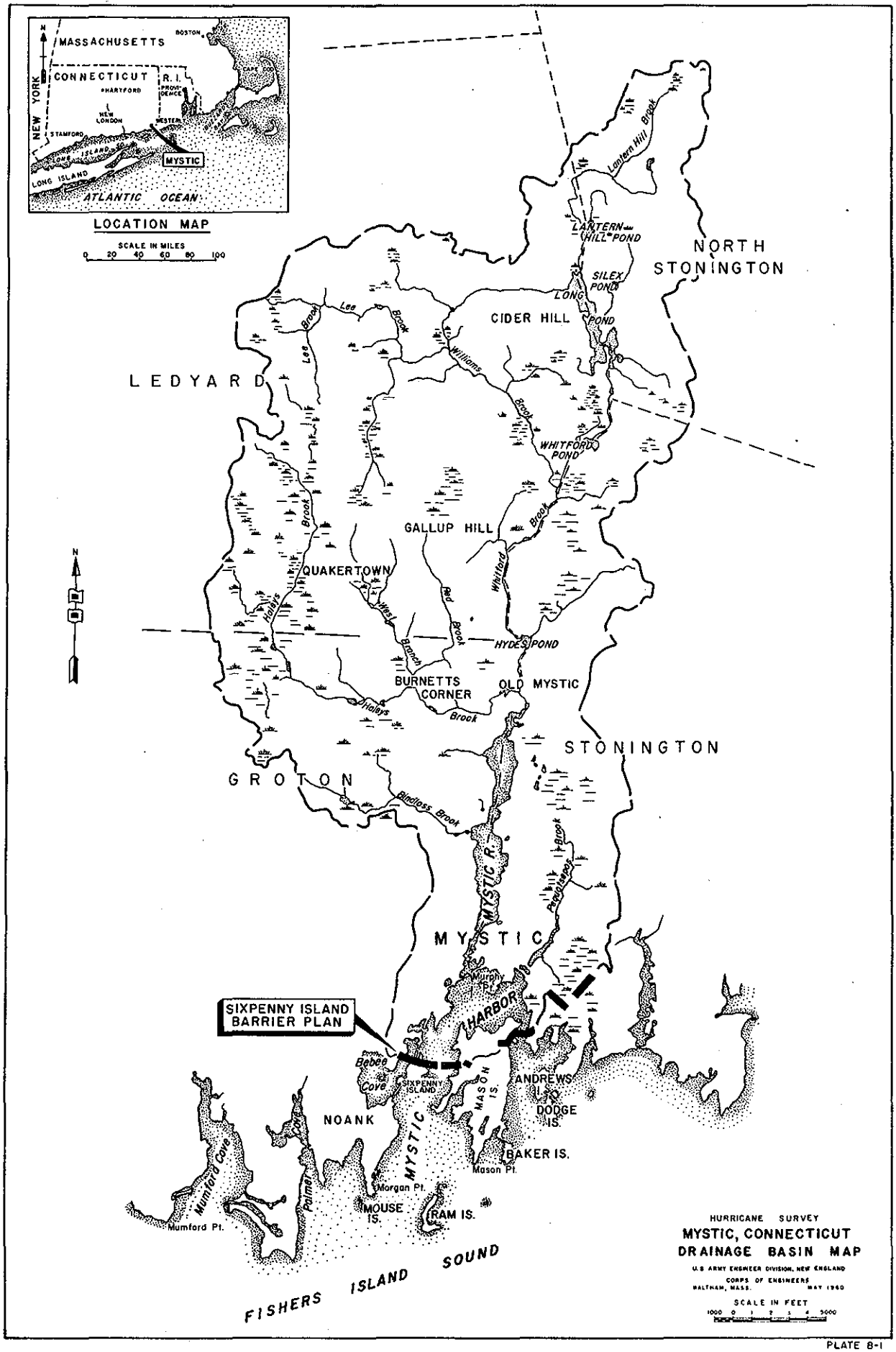
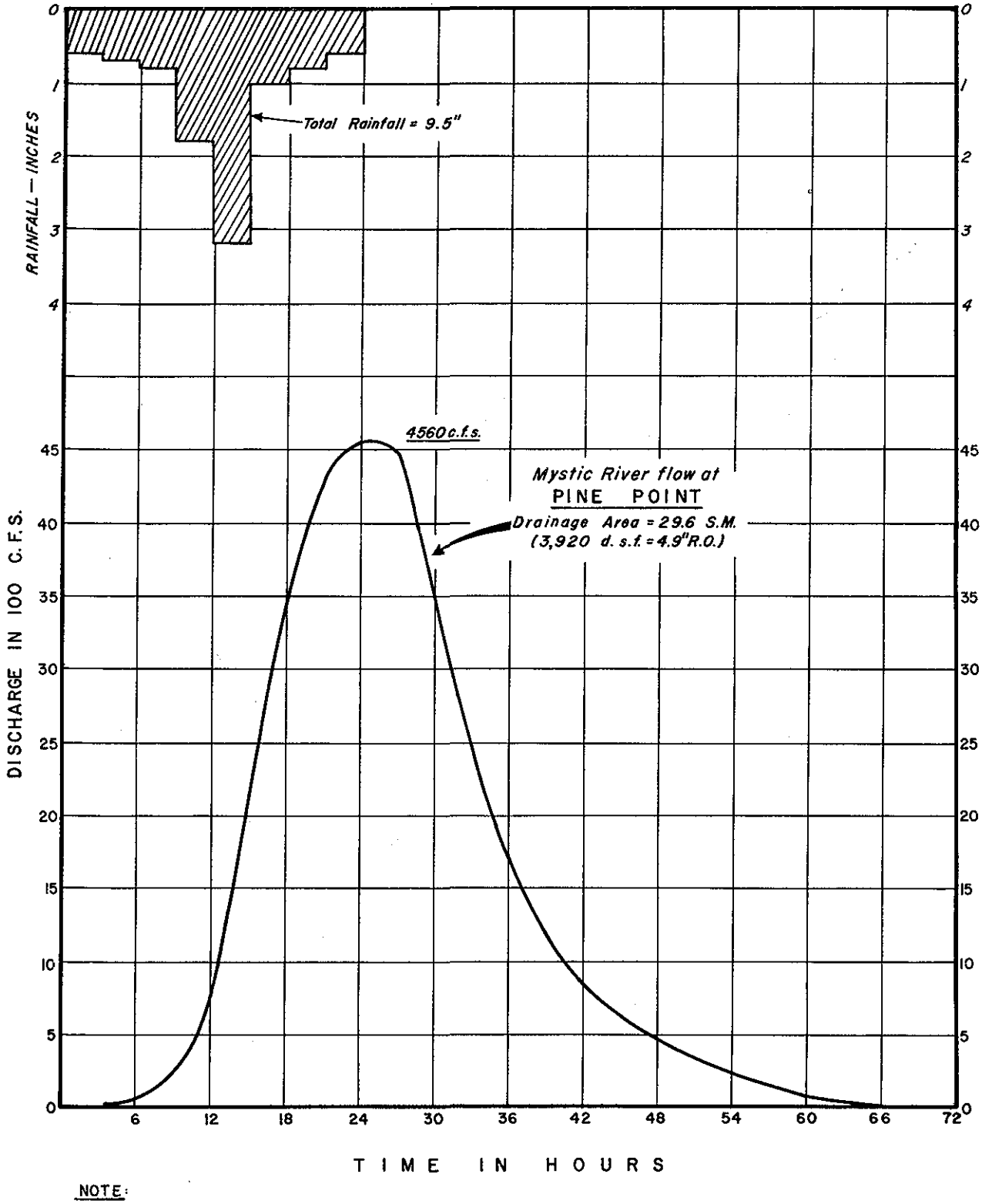

MASSACHUSETTS
BOSTON
CONNECTICUT
R.I.
HARTFORD
PROVIDENCE
NEW LONDON
NEW YORK
STAMFORD
WESTERLY
MYSTIC
LONG ISLAND
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
0 20 40 60 80 100
NORTH STONINGTON
LANTERN HILL POND
SILEX POND
LONG POND
CIDER HILL
LEDYARD
WHITFORD POND
GALLUP HILL
QUAKERTOWN
HYDES POND
BURNETTS CORNER
OLD MYSTIC
STONINGTON
GROTON
MYSTIC
SIXPENNY ISLAND BARRIER PLAN
HARBOR
ANDREWS I.
DODGE IS.
BAKER IS.
NOANK
MOUSE IS.
RAM IS.
Mumford Pt.
Morgan Pt.
Mason Pt.
FISHERS ISLAND SOUND
Lee Brook
Williams Brook
Lantern Hill Brook
Hallys Brook
West Branch
Red Brook
Wartford Brook
Bindloss Brook
Poquonock Brook
Mumford Cove
Palmer Cove
Bebee Cove
MYSTIC R.
HURRICANE SURVEY
MYSTIC, CONNECTICUT
DRAINAGE BASIN MAP
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
MAY 1960
SCALE IN FEET
1000 0 1 2 3 4 5000

PLATE B-1



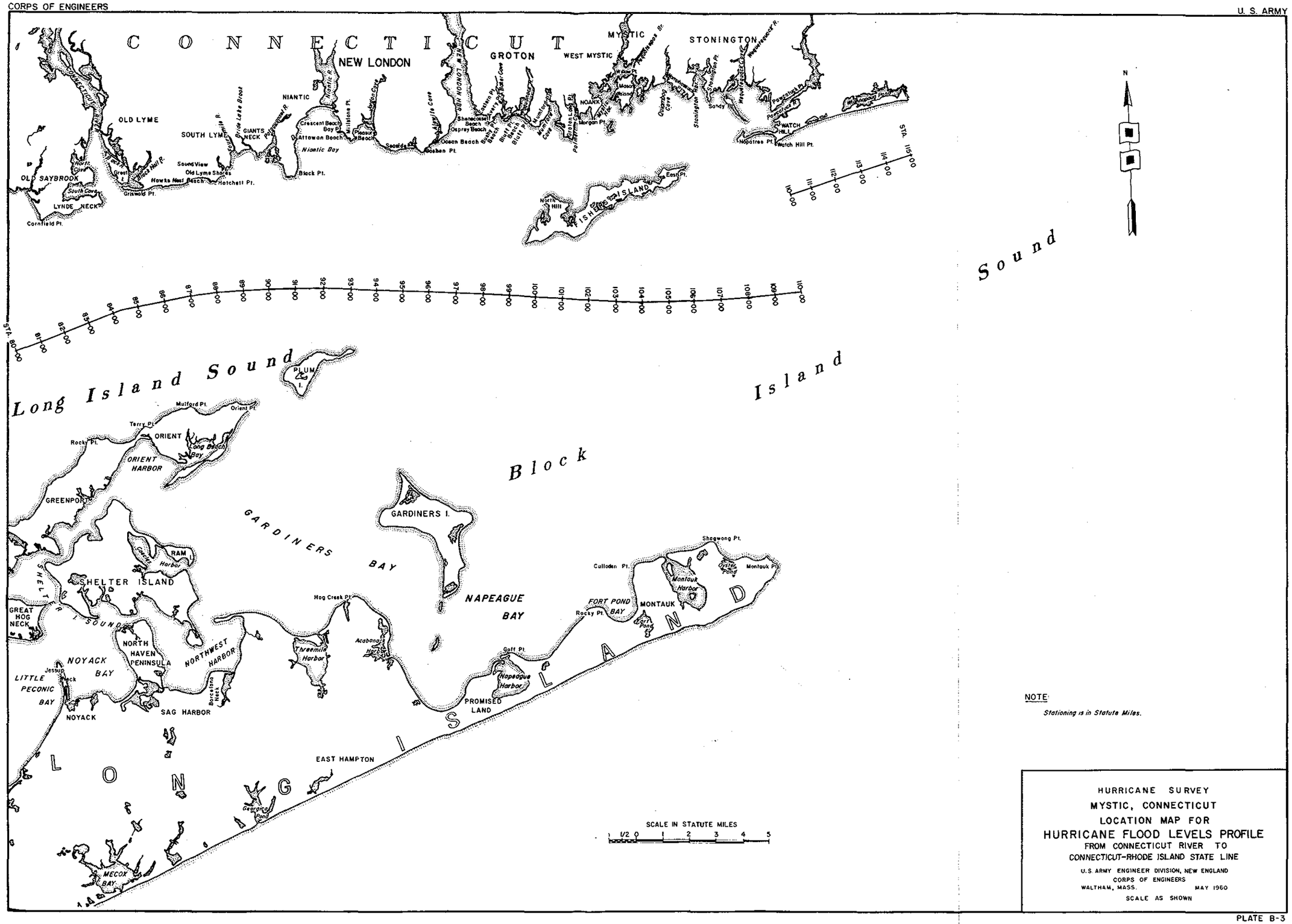
NOTE:
Flow at Pine Point based on hydrograph derived for Moshassuck River at Providence, R. I. (D.A. = 23.8 S.M.)

HURRICANE SURVEY
MYSTIC CONNECTICUT
DESIGN HYDROGRAPH
FROM
TRANSPOSED SEPT. 1938 RAINFALL
AT
SIXPENNY ISLAND BARRIER
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960

PLATE B-2

CORPS OF ENGINEERS

U. S. ARMY



NOTE

Stationing is in Statute Miles.

HURRICANE SURVEY

MYSTIC, CONNECTICUT

LOCATION MAP FOR

HURRICANE FLOOD LEVELS PROFILE

FROM CONNECTICUT RIVER TO

CONNECTICUT-RHODE ISLAND STATE LINE

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

CORPS OF ENGINEERS

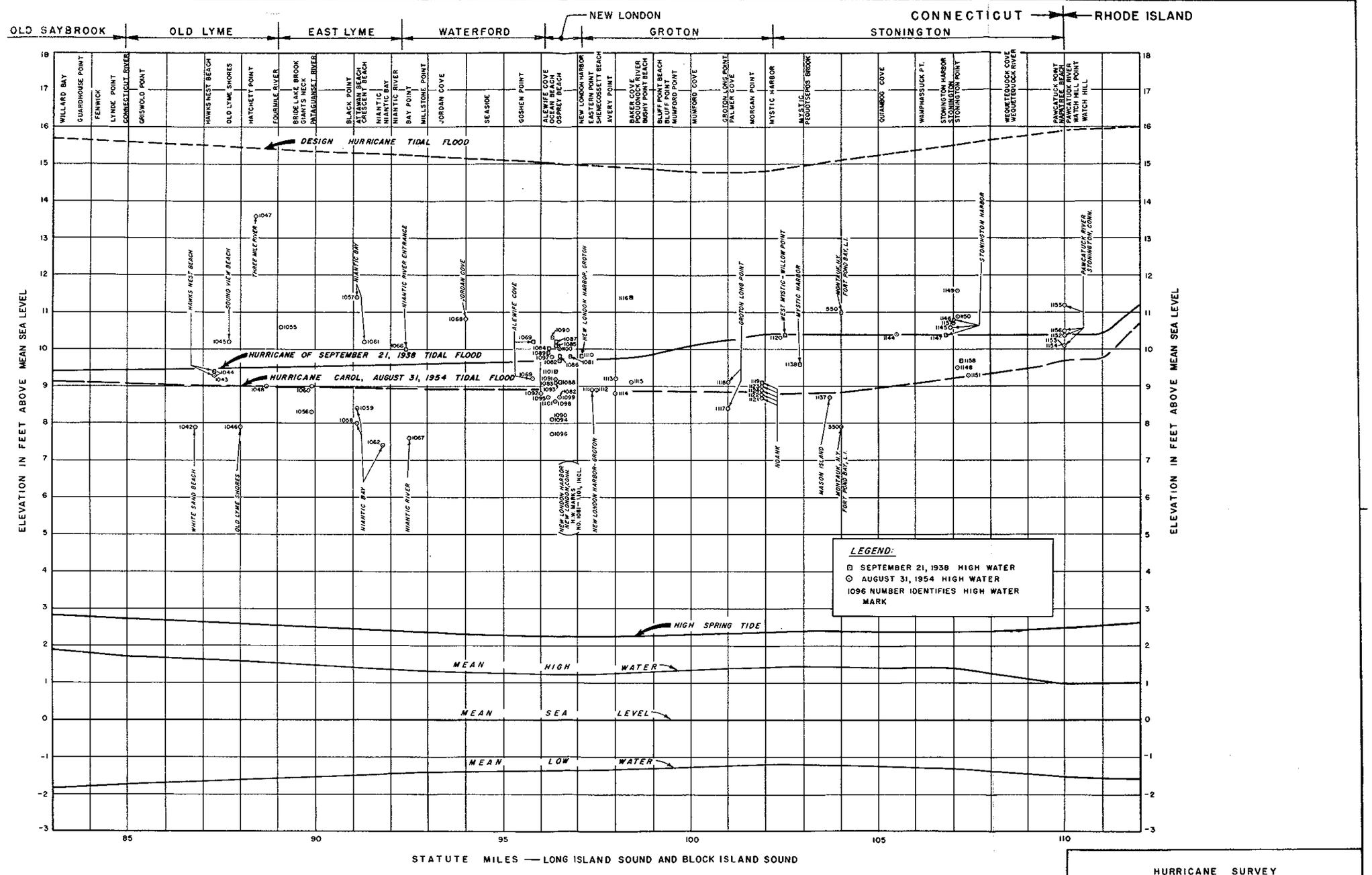
WALTHAM, MASS. MAY 1960

SCALE AS SHOWN

PLATE B-3

CORPS OF ENGINEERS

U.S. ARMY



HURRICANE SURVEY

MYSTIC, CONNECTICUT

HURRICANE FLOOD LEVELS PROFILE

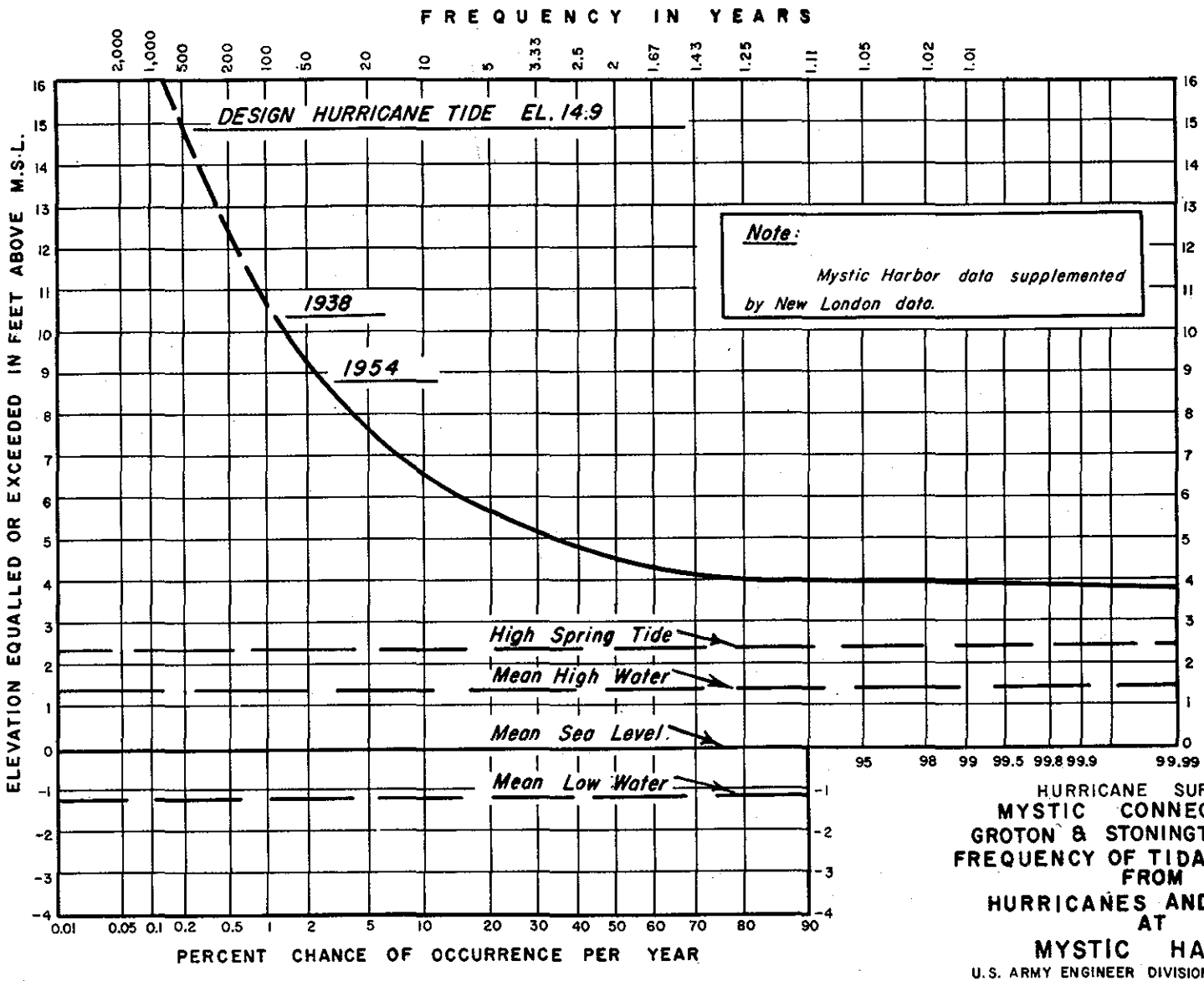
FROM CONNECTICUT RIVER TO

CONNECTICUT-RHODE ISLAND STATE LINE

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960

SCALE AS SHOWN

PLATE B-4



HURRICANE SURVEY

MYSTIC CONNECTICUT
GROTON & STONINGTON CONN.
FREQUENCY OF TIDAL FLOODING FROM HURRICANES AND STORMS AT
MYSTIC HARBOR

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960

PLATE B-5

EL. 14.9

DESIGN HURRICANE TIDE

PREDICTED HIGH SPRING TIDE

EL. 10.4

1938 HURRICANE TIDE

MEAN HIGH WATER

MEAN SEA LEVEL

PREDICTED TIDE

MEAN LOW WATER

EL. 8.8

1954 HURRICANE TIDE

PREDICTED TIDE

ELEVATION — FEET ABOVE MEAN SEA LEVEL

15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.43
1.0
0.0
-1.0
-1.17
-2.0

2 4 6 8 10

TIME IN HOURS

2 P.M. 4 P.M. 6 P.M. 8 P.M. 10 P.M.

6 A.M. 8 A.M. 10 A.M. 12 NOON 2 P.M.

EASTERN STANDARD TIME

DESIGN HURRICANE

21 SEPTEMBER 1938

31 AUGUST 1954

NOTE:

Design hurricane tide curve based on Texas A&M surge calculations for a design storm with a track most critical to Long Island Sound and with the peak of the surge coincident with the peak of a high spring tide.

NOTE:

1938 — Hurricane tide curve based on U.S.C.&G.S. high watermark at Mystic and estimated hurricane tide at Newport, R.I..

NOTE:

1954 — Hurricane tide curve based on high water mark at Mystic and estimated hurricane tide at Newport, R.I..

HURRICANE SURVEY

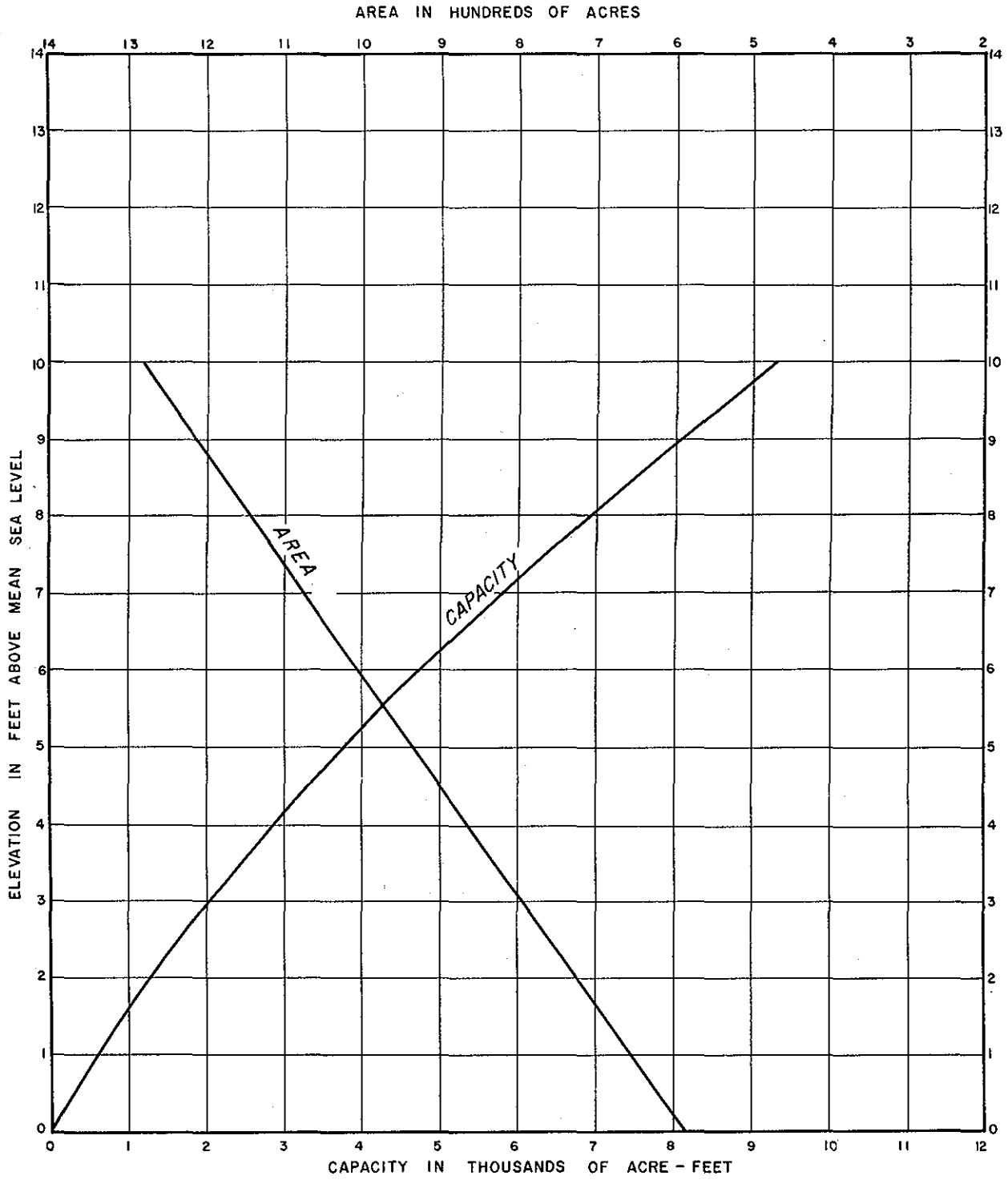
MYSTIC, CONNECTICUT

TIDE CURVES

DESIGN HURRICANE, — 1938 & 1954

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960

PLATE B-6



NOTE

BASED ON U.S.G.S. MAPS.

HURRICANE SURVEY

MYSTIC CONNECTICUT

SIXPENNY ISLAND BARRIER PLAN

AREA AND CAPACITY CURVES

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960

PLATE B-7

APPENDIX C

FLOOD LOSSES AND BENEFITS

APPENDIX C

FLOOD LOSSES AND BENEFITS

GENERAL

C-1. DAMAGE SURVEYS

Damage surveys in the Mystic Harbor area were conducted principally in late 1956. Essentially, the damage survey was a door-to-door inspection of the hundreds of residential, commercial, industrial and other properties affected by tidal flooding. The information obtained included the extent of the areas flooded, descriptions of properties including changed conditions since the 1954 hurricane, the nature and amount of damages, depths of flooding, high-water references, and relationships between 1954 and previous flood stages. Evaluations of damage were generally furnished by tenants or property owners and, if unreasonable, were modified by the investigators. Sampling methods were often used where properties of the same general type were subject to the same depth of flooding. Data on damages to public property, highways, utilities and railroads were obtained from central sources and applied to field information. The survey area included the entire shore line of Mystic Harbor extending from Morgan Point in the Town of Groton to Williams Point in the Town of Stonington, extended about 3 miles up river to the head of the estuary at Old Mystic. Mason Island at the entrance to the harbor was also included. Office and field reviews were undertaken in 1957 and 1960 which incorporate physical changes within the flood area.

Sufficient data were obtained to derive losses at the 1954 flood stage, and at a stage 3 feet higher. The stage of zero damage, that is, the stage where damage begins, was also determined. This stage was referenced to the 1954 flood level. Losses were also obtained for stages where marked increases in damages occurred.

C-2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and by location. The types of loss data recorded included urban (commercial, residential and public), industrial, highway, railroad and utility. The losses were also recorded by subdivisions, such as urban blocks within the flooded area, in order to provide a basis for later use in stage-loss and benefit analyses.

The losses evaluated in the survey were tangible, primary damages. Primary damages comprise the following: (1) physical losses, such as damage to structures, machinery and stock, and cost of cleanup and repairs; and (2) nonphysical losses, such as unrecovered loss of business, wages or production, increased cost of operation, cost of temporary facilities and increased cost of shipment of goods into or out of the inundated areas.

The primary loss resulting from physical damage, and a large part of the related nonphysical loss, were determined by direct inspection of flooded properties and evaluation of the losses by either the property owners or field investigators, or both. The nonphysical portions of the primary loss were often difficult to estimate on the basis of available information. Where this condition existed, the nonphysical losses were estimated by utilizing determined relationships between physical and nonphysical losses for similar properties in the survey area and other areas.

Monetary evaluations were not made of secondary damages or intangible losses. Secondary damages, those incurred outside the immediate flooded area under study, include such items as increased cost of travel and shipment of goods, loss of utilities and transportation facilities, and business losses. Intangible losses include items such as loss of life, hazards to health and detrimental effects on the national security.

HURRICANE TIDAL-FLOOD DAMAGES

C-3. TIDAL-FLOOD LOSSES

The Mystic Harbor area, one of the hardest hit areas on the coast of Connecticut in past hurricanes, sustained serious losses in Hurricane "Carol", 31 August 1954. The hurricane tidal-surge in 1954 occurred about 25 minutes before the peak of the predicted high tide and caused severe flooding throughout the shore areas of the Mystic River, Mystic Harbor and Mason Island. The destructive tidal flooding in 1954 rose 7.4 feet above mean high water in Mystic Harbor, reaching a level 1.6 feet below the record tidal-flood height experienced in 1938. In the study area (from Morgan Point in the Noank section of the Town of Groton to Williams Point in the Mystic section of the Town of Stonington, and including Mason Island at the entrance to Mystic Harbor) tidal flooding caused total damages estimated at $1,450,000. Over 460 structures suffered flood damages, including some 340 dwellings, 110 commercial establishments (including four major boatyards), 4 industrial plants and other public buildings and wharves. Damage areas are described in Table C-1 and are shown on Plate C-1.

C-4. TYPE AND DISTRIBUTION OF EXPERIENCED LOSSES

Residential and commercial buildings located on low ground near the mouth of the Mystic River were particularly hard hit. Approximately 110 commercial firms suffered losses of over $600,000, which represents about 40 percent of the total tidal-flood damage in the Mystic Harbor area. A tabulation of 1954 experienced tidal-flood losses in the Mystic Harbor area is shown in Table C-1 by damage areas and by types of losses.

In Area I, the Noank section of the Town of Groton located west of the harbor and generally south of the northern end of Sixpenny Island, tidal-flooding from Mystic Harbor caused damages amounting to about $130,000. Approximately 20 dwellings and 6 commercial establishments, primarily in the area between Morgan Point and Beebe Cove, experienced up to 2 feet of flooding at the first floor level.

Area II, which includes the commercial district of Groton on the west bank of the Mystic River and the residential Willow Point area, sustained losses totaling about $620,000. Nearly all of the 60 commercial establishments and over one-half of the 75 residential properties in this flood-prone area are located in the half mile reach immediately upstream of the railroad bridge near the mouth of the river. First floor floodings, to depths up to 6 feet, were experienced by some 25 dwellings, 50 commercial establishments and 2 public buildings.

Area III, the largest of the four areas subject to flooding, suffered about 40 percent of the Mystic Harbor losses. This area includes the Mystic and Old Mystic (several miles upriver) sections of the Town of Stonington, as well as two small residential areas and two boat service areas at the northern end of Mason Island, which are located within the Sixpenny Island Plan protection area. Approximately 220 dwellings, 42 commercial establishments and 4 industrial plants were inundated, with almost equal losses in each of the three categories. A major part of the $610,000 loss in Area III was experienced in the mile reach between the Marine Historical Association and the railroad bridge, where most of the 40 structures with first floor damage were located. Floodings to depths up to 4 feet were experienced in the area immediately upstream of the highway bridge.

Losses in the Mason Island area outside the Sixpenny Island Plan protection, Area IV, amounted to about $90,000. Approximately 24 large homes and a yacht club were exposed to heavy wave action. Damages to piers and sea walls accounted for nearly half of the island losses. Flooding at the ground-floor level was limited to the yacht club. In addition to residential, commercial and industrial losses in the Mystic Harbor area, damages sustained by craft afloat and by transient automobiles in the flooded area accounted for losses which were not included in the tabulations of damages, or were included only in part, since specific information on these losses was meager or unavailable. Available evidence indicates, however, that losses of this nature were substantial in both the 1938 and 1954 hurricanes.

C-5. RECURRING LOSSES

Stage-loss curves, referenced to the 1954 tidal-flood level, have been developed as the basis for economic analysis. These stage-loss curves, prepared from data collected in the recent damage surveys, afford a means of determining the magnitude of recurring losses at any stage of flooding up to a stage 3 feet above that experienced in 1954. The recurring losses used in development of the stage-loss relationship reflect economic

TABLE C-1

EXPERIENCED TIDAL-FLOOD LOSSES IN MYSTIC HARBOR AREA

HURRICANE "CAROL," 31 AUGUST 1954

Towns of Groton and Stonington, Connecticut

Area	Description	Losses in Thousands of Dollars				
		Urban	Industrial	Highway	Railroad	Total
I	Groton Area (Noank) south of northern end of Sixpenny Island	80	--	10	40	130
II	Groton Area north of northern end of Sixpenny Island	560	--	10	50	620
III	Stonington Area (Mystic and Old Mystic) east of Mystic Harbor and the Mystic River	420	150	10	30	610
IV	Mason Island Area (Stonington), excluding northern third of the island	90	--	--	--	90
	Total	1,150	150	30	120	1,450

and physical changes in the area since 1954 as revealed by the damage survey. Recurring stage-loss data for individual properties, referenced to the peak elevations for the 1954 hurricane flood, have been summarized for the areas afforded protection by the Sixpenny Island Plan.

A number of primary flood losses, both tangible and intangible, have not been included in the economic analyses of protective measures, even though these losses may be substantial in a given instance of tidal flooding. Tangible losses in this category are made up of (1) damages to vehicles either underway or parked on the street or in public or commercial parking lots, and (2) damages to more than 300 small craft and vessels afloat at shore facilities, or on the open water within the protection area, which are subject to an indeterminate combination of wind, waves and tide. These categories of losses consist of damages to items which are not always present in the same place, at the same time or in the same quantity. To put losses in this category in perspective for analysis would require a framework of multiple assumptions.

A breakdown of the losses to be anticipated in the Mystic Harbor flood area and in the areas protected by the Sixpenny Island Hurricane Protection Plan, in the event of future hurricanes, is shown at the 1960 price level in Table C-2.

ANNUAL LOSSES AND BENEFITS

C-6. GENERAL

The total benefit of the plan to control hurricane tidal-flooding in the Mystic Harbor area is made up of tidal flood damage-prevention benefits and benefits from the elimination of scare costs. The flood damage-prevention benefits are by far the most important. The annual benefits of such nature attributable to the Sixpenny Island Hurricane Protection Plan at Mystic Harbor have been determined in accordance with standard practices of the Corps of Engineers by utilizing stage-loss and stage-frequency data to develop damage-frequency relationships.

C-7. AVERAGE ANNUAL TIDAL-FLOOD LOSSES

Tidal-flood losses in the Mystic Harbor area have been converted to average annual losses by correlating stage-loss and stage-frequency relationships to derive damage-frequency curves. The stage-frequency curve is based upon the known peak elevations in the hurricanes of 1938 and 1954 and on the stages for other hurricanes and storms, for the period July 1938 - December 1956, inclusive, as estimated from the record of the U. S. Coast and Geodetic Survey tide gage located in New London Harbor.

TABLE C-2

RECURRING TIDAL-FLOOD LOSSES IN MYSTIC HARBOR AREA

Towns of Groton and Stonington, Connecticut
(1960 Price Level)

Recurring Hurricanes	Flood Stage (feet, msl)	Entire Flooded Area	Sixpenny Island Plan Protected Area
31 Aug. 1954	8.8	$1,650,000	$1,400,000
14 Sept.	6.1	160,000	150,000
21 Sept. 1938	10.4	3,820,000	3,280,000
Other Storms			
7 Nov. 1953	5.8	120,000	120,000
25 Nov. 1950	6.6	250,000	240,000

The stage-loss curve has been combined with the stage-frequency curve to develop a damage-frequency curve which has been plotted with damage as the ordinate and with percent-chance-of-occurrence (the reciprocal of frequency) as the abscissa. See Plate C-2. The area under this damage-frequency curve is a measure of the average annual loss. The average annual loss in the Mystic Harbor area developed to the design hurricane tide level of 14.9 feet, m.s.l., is estimated at $192,000. The average annual loss in the area protected by the Sixpenny Island Plan also developed to the design hurricane tide of 14.9 feet, amounts to $165,000.

C-8. ANNUAL DAMAGE-PREVENTION BENEFITS

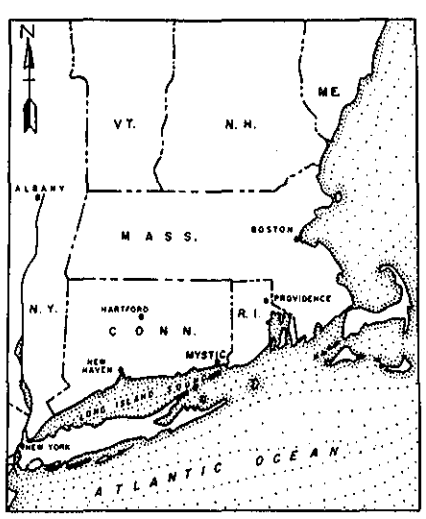
Average annual benefits from the prevention of tidal-flood damages have been derived by determing the difference between the average annual losses under present conditions and the average annual losses remaining after construction of the protection. The average annual flood-damage prevention benefits attributable to the plan total about $165,000.

C-9. SCARE COST BENEFITS

In addition to actual tidal-flood damage, significant losses are sustained in areas subject to tidal flooding due to the cost of setting temporary protective measures into operation following the receipt of hurricane warnings. Based on data gathered in the course of damage surveys in the Mystic Harbor area and in other areas subject to tidal flooding, it is estimated that 25 percent of the commercial establishments and 50 percent of the industrial concerns in the flooded area attempt to minimize their potential losses through temporary prevention measures. The estimated benefits to the Sixpenny Island Plan by eliminating scare costs incurred in a single hurricane warning, amount to $24,000. Based on a frequency of four hurricane warnings in a 10-year period, the average annual benefit from the elimination of scare costs amounts to $10,000.

C-10. SUMMARY OF BENEFITS

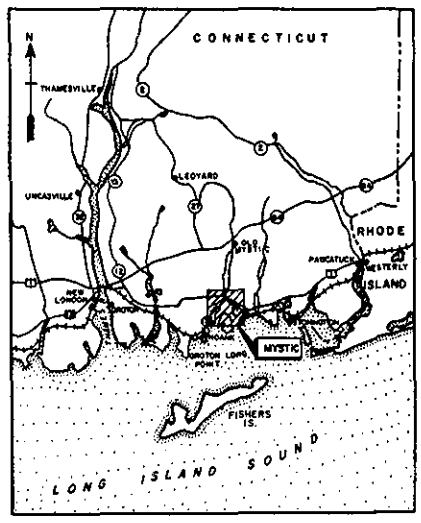
Total annual benefits of $175,000 attributable to the protection provided by the Sixpenny Island Plan include $165,000 in average annual flood-damage prevention benefits and $10,000 in the elimination of scare costs.



LOCATION MAP

SCALE IN MILES

25 0 50 100



VICINITY MAP

SCALE IN MILES

0 1 2 3 4 5 6

OLD MYSTIC

HYDES POND

RED BROOK

HALEYS BROOK

STONINGTON

BINDLOSS BROOK

MYSTIC RIVER

AREA III
$1,610,000

PEQUOTSEPOS BROOK

COPPS BROOK

GROTON

AREA II
$1,630,000

MYSTIC

FISHBROOK BROOK

MURPHY PT.

WILLOW PT.

HARBOR

PINE PT.

SPENCE PT.

WILLIAMS PT.

AREA I
$ 350,000

BEBEE COVE

SOUDEN SQ.

MASON ISLAND

ANDREWS IS.

LYDDY IS.

RAM PT.

DODGE IS.

NOANK

N.Y.N.H.&H.R.R.

AREA IV
$ 230,000

MASON PT.

MORGAN PT.

MOUSE IS.

GATES IS.

RAM IS.

SOUND

ISLAND

FISHERS

SCALE IN FEET

1000 0 1000 2000 3000

LEGEND

FLOODED AREA 1938 HURRICANE

DAMAGE AREA OUTLINES

$3,820,000

TOTAL RECURRING 1938 TIDAL—FLOOD LOSSES AT 1960 PRICE LEVEL

HURRICANE SURVEY

MYSTIC, CONNECTICUT

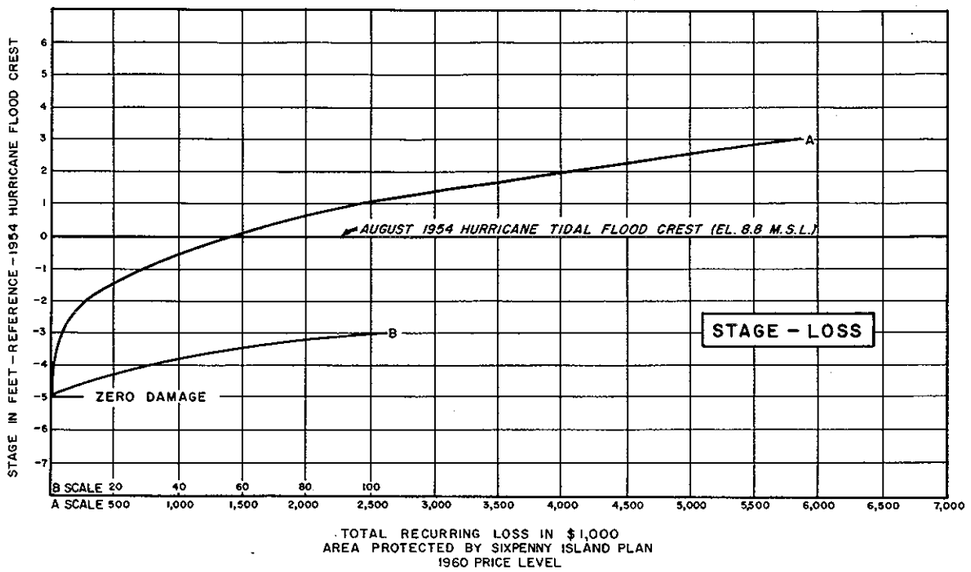
FLOOD AREA AND DAMAGES

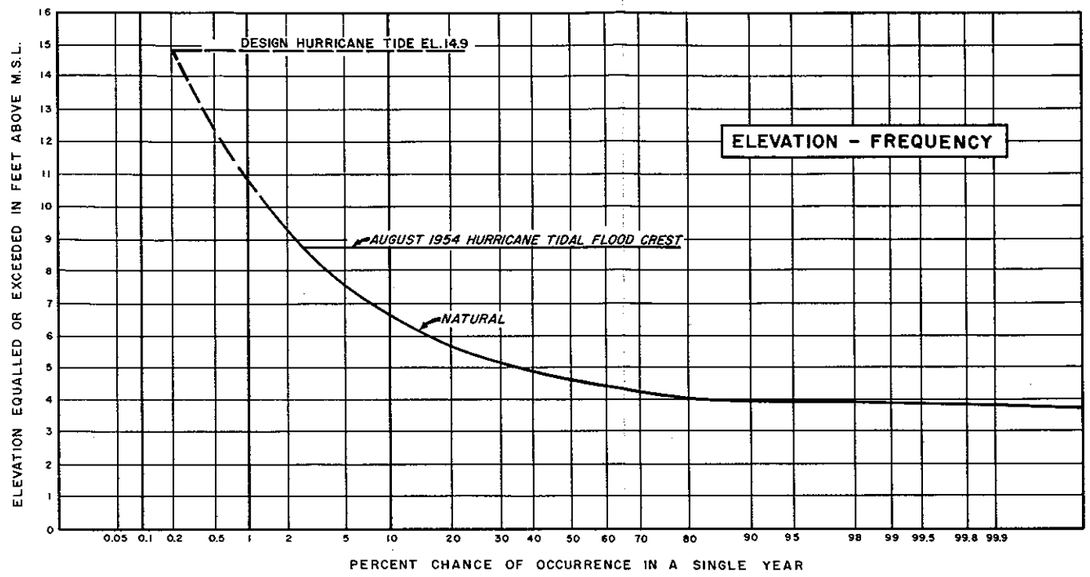
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. MAY 1960

SCALE AS SHOWN

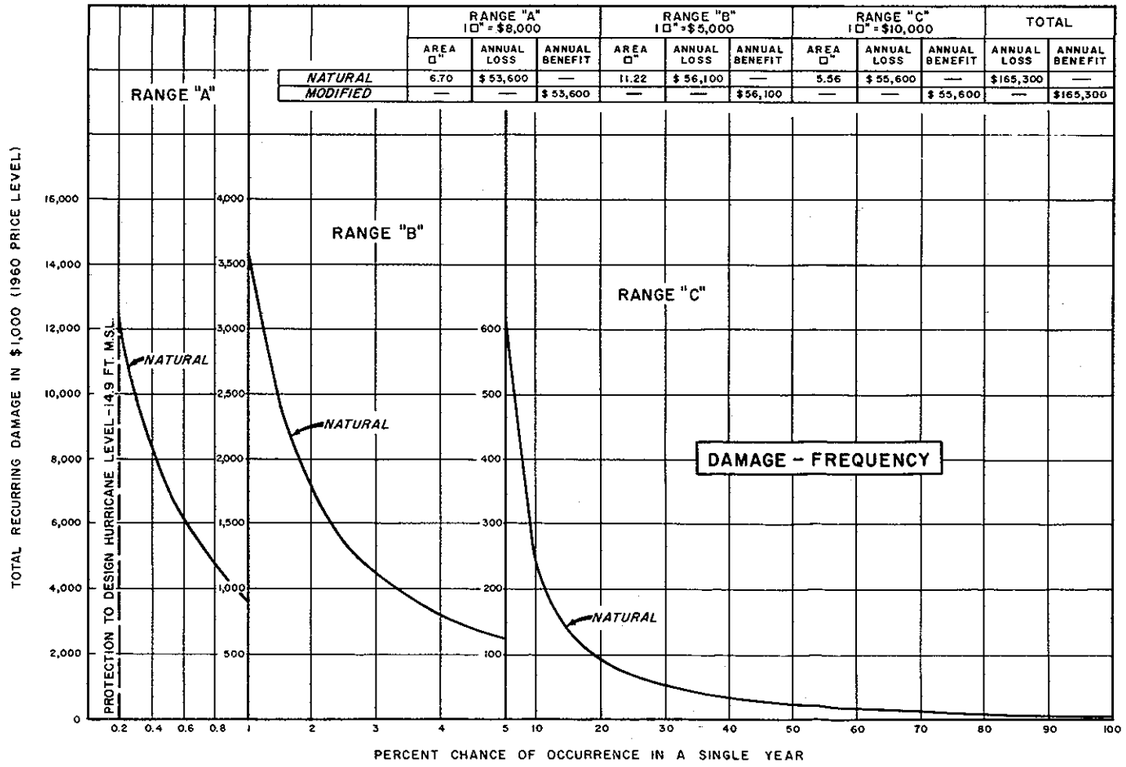
PLATE C-1

PLATE C-1





	RANGE "A" □" = $8,000			RANGE "B" □" = $5,000			RANGE "C" □" = $10,000			TOTAL	
	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL	6.70	$ 53,600	—	11.22	$ 56,100	—	5.56	$ 55,600	—	$165,300	—
MODIFIED	—	—	$ 53,600	—	—	$56,100	—	—	$ 55,600	—	$165,300



HURRICANE SURVEY

MYSTIC, CONNECTICUT
SIXPENNY ISLAND PLAN
CURVES FOR ECONOMIC ANALYSIS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. JUNE 1960

PLATE C-2

APPENDIX D

GEOLOGY AND FOUNDATION DATA

APPENDIX D

GEOLOGY AND FOUNDATION DATA

D-1. PHYSIOGRAPHY AND GEOLOGY

Mystic Harbor lies on the seaboard lowland of the New England physiographic province, in the estuary of the Mystic River at Long Island Sound, in southeastern Connecticut. The east side of the river mouth possesses a small coastal marsh. One large island, Mason Island, displays bedrock and longitudinally divides the outer harbor. Frequent bedrock exposures occur along both sides of the western branch, which is used for shipping, while the eastern branch is narrow and blocked by a causeway and road which connect Mason Island to the mainland, permitting tidal movement only beneath a small bridge. To the north, railroad and highway draw bridges permit access to the inner harbor in the business district of the town, and to the channel extending about three-quarters of a mile above the highway bridge.

Hills exceeding 100 feet in elevation flank the harbor on both sides and to the north. Bedrock is exposed frequently, but glacial till is common at higher elevations, while occasional glacial, silty gravelly sands occur at lower elevations as flanking terraces.

The most prominent subsurface geological feature is a deep pre-glacial depression, possibly a valley, carved in the massive granite-gneiss bedrock. Borings for this survey indicate that the depression if continuous, probably runs under the eastern portion of the business district of Mystic, then turns sharply to pass into Long Island Sound via the east side of Mason Island. Based on past experience in Narragansett Bay and on the depth and character of the sediments near the railroad bridge at Mystic, it appears probable that the large depression is 100 feet or more in depth. If so, fine sands and silts occurring in the harbor at the railroad bridge and at the causeway below elevation -20 feet may decrease in grain size within the depression, and overlie glacial marine clays before bedrock is reached. The passage west of Mason Island appears to be a saddle of sufficient depth to have received an overflow of the fine-grained glacial sediments deposited in the larger depression to the north.

D-2. SUBSURFACE INVESTIGATIONS

a. General. No existing subsurface information was available other than approximate depths of pile penetration for the railroad swing bridge. Subsurface explorations consisting of 18 drive sample borings and 10 hand probings were made by the Corps of Engineers in the late spring and early summer of 1957 and in the winter of 1960. The locations of all explorations are shown on Plate D-1.

b. Railroad Embankment Site. Two harbor foundation borings and three land foundation borings were located along the railroad embankment crossing.

c. Pine Point Site. Three foundation borings were located in the water to the west of Pine Point, and one land foundation boring was located on the west abutment marsh crossing.

d. Sixpenny Island Site. (Recommended Plan). Three foundation borings were located east of Sixpenny Island, and 10 hand probings were made on and west of the island.

e. Auxiliary Dikes. (Recommended Plan). Three foundation borings were made along the causeway crossing east of Mason Island, and three more beside U. S. Route No. 1, for dike closures along the Pine Point Plan alignment, also applicable to the Sixpenny Island Plan.

D-3. FOUNDATION CONDITIONS IN THE HARBOR

a. Sixpenny Island Plan, Harbor Crossing West of Mason Island. The water depths range from tidal to about elevation -18 feet, m.s.l., the greater depth localized in and immediately adjacent to the channel. An organic silt blanket ranging in thickness (except near the shore) from about 5 feet to 20 feet lies on the bottom, the lesser thickness existing under the navigation channel. The maximum thickness of organic silt appears to exist adjacent to the western bank of the navigation channel, where maximum overburden thickness of about 60 feet is attained. Sands and gravels, in part silty, underlie the harbor mud in thicknesses ranging from 7 or 8 feet near the channel to about 20 feet near the islands. These deposits become more consolidated in alignment approach to Sixpenny Island. A thin, peat layer, however, occurs in that area between the harbor mud and the granular materials. A deposit of laminated silts and fine sands with some gravel attains a maximum thickness of about 18 feet beneath the sand and gravel at the west channel bank, thinning out toward the islands. Directly overlying bedrock, finally, is a pocket of silty gravelly sand, thinning out toward Mason Island but grading into glacial till toward Sixpenny Island. Bedrock, consisting of granitic and biotitic gneiss, is only slightly weathered, is massive, and occurs at elevation -44.4 feet just east of Sixpenny Island, appears at the surface adjacent to the east abutment and lies at elevations -48.6 and -64.1 feet east and west, respectively, of the gate structure, indicating a probable range of elevation beneath the structure of -55 to -60 feet. Conditions west of Sixpenny Island have been very preliminarily explored by means of 10 hand-hammered probings. These probings indicate the presence of a maximum thickness of about 5 feet of soft organic silt. A geologic section at this barrier location is shown on Plate D-2.

b. Pine Point Site, Harbor Crossing West of Mason Island. Water reaching depths of about 20 feet overlies 1-16 feet of soft organic silt. Organic silts along the east half of the crossing extend to a fairly even elevation of about -26 feet, m.s.l. Westward, they decrease steadily to less than

1 foot at the west abutment. Sands and silty sands take their place in this area, down to about minus elevation 22 feet on the west and -24 feet in the middle. All the foregoing materials overlie silts and silty sands down to about elevation -40 feet on the west and elevations minus 54-56 feet at the center and on the east. Blow counts in all the preceding materials averaged 20 blows per foot of penetration or less. Two to six feet of moderately firm gravels, till-like material in part, underlie these materials and rest on bedrock. Bedrock appears on both abutments and was determined in two borings near the middle to occur at minus elevations of 61.2 feet on the west and 62.4 feet on the east. The rock, in every case granitic-gneiss, was hard, moderately fresh, and in good condition. A geologic section at this barrier is shown on Plate D-3.

c. Causeway Crossing and Gated Boat Opening East of Mason Island (Recommended Plan). A little more than 20 feet of variably moderate to highly compact complexly bedded sands, gravels and silts overlie a trough of undetermined depth, containing lightly compacted very fine sands and silts to an explored depth of 40 feet. Two feet of organic silty gravel were encountered in a boring placed through the causeway, representing a mixture of the embankment fill placed over organic silt of a probable 3 foot thickness. The west abutment of the causeway consists of highly compacted variably sandy silty gravels, 14 feet thick, overlain by two feet of slightly compacted silty sand. Bedrock was encountered directly beneath these materials at an elevation of approximately -13 feet. The east abutment consists of a foot of topsoil overlying 18 feet of moderately compact sandy gravel, resting on 5 feet of poorly compacted sand, overlying very fine sands and silts of unknown depth. A geologic section at this barrier is shown on Plate D-3.

d. Railroad Embankment Site. Shallow water overlies 4 to at least 20 feet of soft organic silt along the crossing. The least thickness occurs on the east shore, increasing toward the west until the maximum thickness determined was reached, 100 feet west of the west edge of the ship channel. Underlying the organic silt is a mass of fine sands, occasionally silty, extending to elevations of minus 32-34 feet, m.s.l., sloping slightly downward east to west. Very fine sandy silts underlie the fine sands to a known depth of at least elevation -73 feet west of the ship channel. East of the channel a boring was discontinued at elevation -58 feet, still in similar material. This predominantly silt mass was observed to consist in part of very fine sands. None of the materials were observed to be very compact. Bedrock occurs on the west abutment, but was not definitely established in the explorations. One boring 100 feet west of the channel was probed to refusal at elevation -81.7 feet. A geologic section at this barrier is shown on Plate D-4.

D-4. FOUNDATION CONDITIONS FOR LAND DIKES

a. Sixpenny Island Plan-Land Dikes. (Recommended Plan). Both abutments for the marsh crossing along U. S. Route No. 1 are bedrock knobs. A small knoll divides the marsh at the center and a lower rise occurs 800 feet to the east. A boring placed between these features indicated 18.1 feet of sand to the bedrock surface at elevation -10 feet. The lower 10 feet of sand was well compacted while the upper sand was moderately loose. Blocks and boulders on the surface of the larger knob indicate a probable rise of the bedrock surface. The center of the marsh to the east was found to consist of a thin skim of organic silt (about a foot) underlain by alternating thin layers of fairly compact sands, gravels and silts, with sands predominating, down to a compact gravel zone occurring at about elevation -28 feet, overlying refusal material, presumed bedrock, at approximately elevation -33 feet. West of the center, silt predominates over the sand, all lightly to moderately compacted. A thin (1-2 feet) clay layer occurs at minus elevation 22 feet overlying 3.5 feet of compact silty sandy gravel, which in turn tops a very compact gravelly till-like material of undetermined thickness. An additional dike, Land Dike A, is small and while marshy in part, abuts on bedrock and should provide no serious foundation problems. A geologic section at this alignment is shown on Plate D-3.

b. Railroad Embankment Site - Land Dike. A consistency of materials exists at this site. Above elevation minus 30-32 feet are rather poorly compacted sands, essentially fine sands, silty in part. Below that elevation are very fine sandy silts, silty very fine sands in part, of unknown depth. The eastern abutment is a bedrock knob.

D-5. AVAILABILITY OF CONSTRUCTION MATERIALS

a. Earthen Borrow. Land sources for both pervious and impervious borrow sufficient for construction of the barrier and dikes can be obtained within a five mile haul distance. In addition, a few commercial sources of sand and gravel are located about the periphery of the five mile haul area. Portions of the material obtained by dredging the bypass channel around the cofferdam may prove suitable for utilization in the main barrier together with sandy materials borrowed by dredging in the inshore flanks of Sixpenny Island.

b. Rock Borrow. Almost any local bedrock exposure of sufficient elevation is suitable for quarrying and should produce good quality material in riprap and capstone sizes. A quarry was opened in 1880 on Mason Island, near the abutment of the Pine Point alignment, for the sole purpose of providing breakwater stone. The quarry has long been inactive, however, and recent high quality residential development of the island appears to have disqualified the island as a practical source of stone.

Two major commercial granite sources lie in Westerly and Bradford, Rhode Island, respectively, 9 and 14 miles haul distances from the site. Other commercial trap rock sources which may offer competitive prices at the site lie near New Haven, Connecticut.

c. Concrete Aggregates. Three commercial ready-mix plants lie within a ten mile haul of the site. These sources have not been tested but it is considered likely that they will prove satisfactory, judging from the favorable character of the country rock and local outwash deposits.

GROTON

STONINGTON

MYSTIC

PEQUOTSEPOS RIVER

MYSTIC HARBOR

MASON ISLAND

Murphy Point

Willow Point

Pine Point

Spence Point

Clam Point

Sixpenny Island

Andrews Island

Babcock Cove

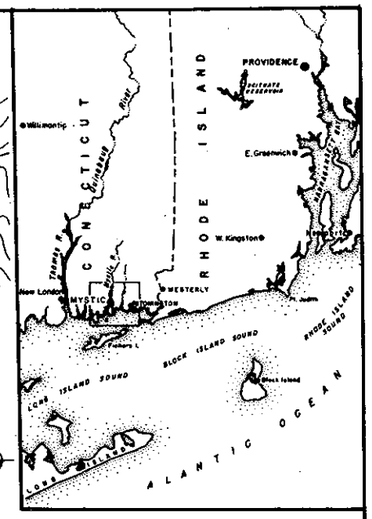
GROTON
STONINGTON

FD-1 FD-2 FD-3 FD-4 FD-5 FD-6 FD-7 FD-8 FD-9 FD-10 FD-11 FD-12 FD-13 FD-14 FD-15 FD-16 FD-17 FD-18

A B C D E

1 2 3 4 5 6 7 8 9 10

N



GENERAL LOCATION MAP

SCALE IN MILES 10 0 10 20

NOTE:
Grid based on Connecticut and Long Island rectangular coordinate systems. Datum is mean sea level.

PLAN OF EXPLORATIONS

SCALE IN FEET 400' 0 400' 800'

LEGEND

- FD — *Foundation Test Boring*
- 9 — *Foundation Probe*
- A——A — *Location of Geologic Sections and Geologic-Log Section*
- *Bedrock Exposure*

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
C.G.H.	H.L.M.	H.C.G.

SUBMITTED: Chief, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED: Chief, FOUNDATIONS BRANCH
RECOMMENDED: Chief, PLANS & SPECS BRANCH
APPROVED: Chief, ENGINEERING DIVISION

HURRICANE SURVEY
MYSTIC, CONNECTICUT
PLAN OF FOUNDATION EXPLORATIONS

DATE MAY 1960

TO ACCOMPANY REPORT
DATED 15 JULY 1960

SCALE: AS SHOWN

DRAWING NUMBER
MYC-2-1000

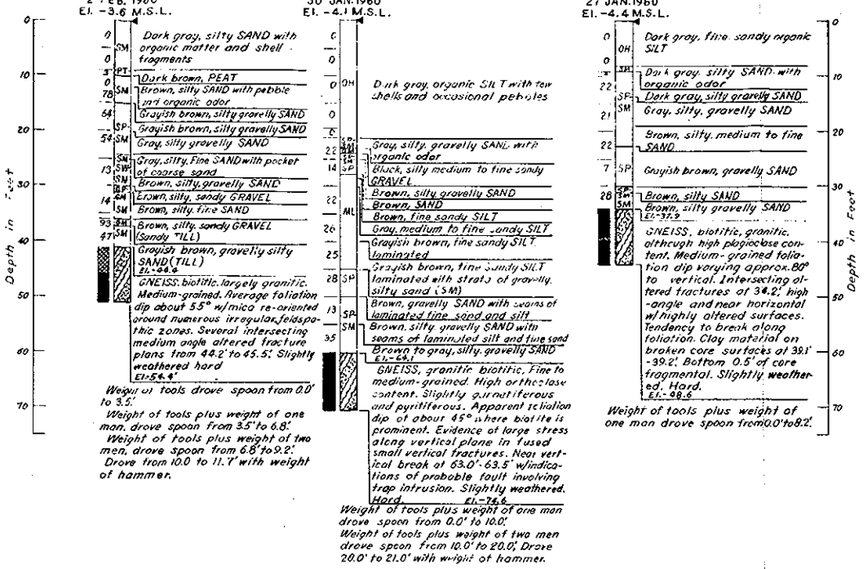
SHEET 1 OF 4

PLATE D-1

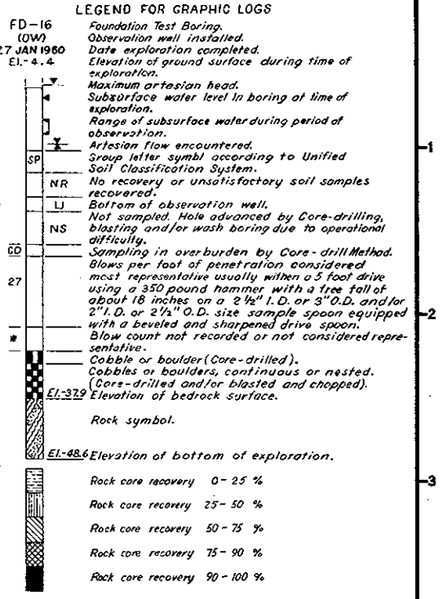
CORPS OF ENGINEERS — U. S. ARMY

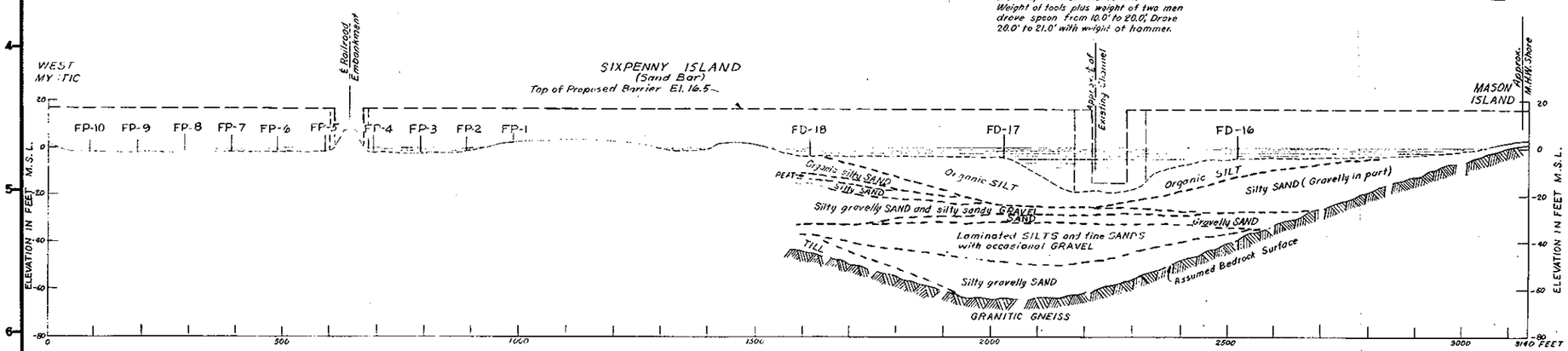
PROBE TABLE

PROBINGS DESIGNATION	APPROX. ELEVATION M.S.L.	BOTTOM THICKNESS PROBED(FT)	REMARKS
FP-1	+2.0	3.2	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 1.7', weight of 1 man. Drove from 1.7' to 3.7', 30 blows with an 8 lb hammer.
FP-2	-1.6	3.5	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 2.0', weight of 1 man. Drove from 2.0' to 3.5' 30 blows with an 8 lb hammer.
FP-3	-2.5	3.6	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 3.1', weight of 1 man. Drove from 3.1 to 3.6', 30 blows with an 8 lb hammer.
FP-4	-2.0	4.8	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 0.4', weight of 1 man. Pushed pipe from 0.4' to 4.1', weight 2 men. Drove from 4.1' to 4.8', 30 blows with an 8 lb hammer.
FP-5	-2.0	4.2	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 3.2', weight of 1 man. Drove from 3.2' to 4.2', 30 blow. with an 8 lb hammer.
FP-6	-2.0	4.0	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 3.2', weight of 1 man. Drove from 3.2' to 4.0', 30 blows with an 8 lb hammer.
FP-7	-2.0	4.7	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 3.9', weight of 1 man. Drove from 3.9' to 4.7', 30 blows with an 8 lb hammer.
FP-8	-2.0	4.5	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 4.0', weight of 1 man. Drove from 4.0' to 4.5', 30 blows with an 8 lb hammer.
FP-9	-2.0	4.4	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 3.3', weight of 1 man. Drove from 3.4' to 4.4', 30 blows with an 8 lb hammer.
FP-10	-2.0	2.9	No solid refusal. Pushed 3/4" plugged pipe from 0.0' to 1.1', weight of 1 man. Drove from 1.1' to 2.9', 30 blows with an 8 lb hammer.



LEGEND FOR GRAPHIC LOGS





GEOLOGIC SECTION E-E (MAIN BARRIER)

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY CGH | DR. BY H.C.S. | CK. BY R.C.G.

SUBMITTED: Geo. Hardy, SOILS GEOLOGY SECTION
PROJECT ENGINEER: C.E. Wentworth
APPROVAL RECOMMENDED: R.A. Lincoln, CHIEF, FOUNDS & EARTH BRANCH
APPROVAL RECOMMENDED: [illegible], CHIEF, PLANS & SPECS BRANCH
APPROVED: [illegible], CHIEF, ENGINEERING DIVISION

HURRICANE PROTECTION
MYSTIC, CONNECTICUT
GEOLOGIC SECTION AND RECORD OF EXPLORATIONS NO. 1

DATE MAY 1960

TO ACCOMPANY REPORT
DATED 15 JULY 1960

SCALE AS SHOWN
DRAWING NUMBER
MYC-2-1001
SHEET 2 OF 4

PLATE D-2

CORPS OF ENGINEERS

U. S. ARMY

FD-12
2 Aug. 1957
El. -3.1

0	OL	Black, sandy, organic SILT
5	SP	Brown, med. to fine SAND
15	SP-SM	Gray, silty, med. to fine SAND
10	SM	Silty, very fine SAND
10	ML	Gray, fine sandy, SILT
9		
18		Grayish brown, very fine sandy, SILT
61	SP-SM	Brown, gravelly, silty SAND

El. -43.0 (Till - Like Material)
Refusal 100 blows

FD-11
30 July 1957
El. -4.4

0	OL	Gray, organic SILT
0		
0		
1		Brown, organic SILT
11	SP	Gray SAND
	ML-SM	Brown SILT (Laminated)
		Orange, silty, coarse to med SAND
12	ML	Gray SILT
19		
4	SM	Gray, silty, very fine SAND
20		NR
19	SM	Gray, silty, med. to very fine SAND
34	GP-GM	Gray, silty, sandy GRAVEL

El. -61.2
GNEISSIC SCHIST Grey. Core segment from 65.6' to 73.2' is almostt pink feldspar. High-angle fissure at 74.3' intruded with greenstone. Lower 3' of core consists of approximately 65% pink feldspar + 35% dark minerals, with occasional fissures sealed by greenstone. Probably xenolithic.
El. -77.1

FD-13
7 Aug. 1957
El. -17.4

0	OL	Black, organic SILT
0		
7	ML-CL	Gray, clayey SILT
8		
9	ML	Gray SILT
5		
12		Gray, very fine sandy, SILT
15	SM	Tan, silty, very fine SAND
	SP-SM	Tan, gravelly, silty SAND
38	SP	Tan, gravelly SAND

El. -62.4 (Till-Like Material)
GRANITE-GNEISS Light grey. Fine grained. High in quartz, with hornblende. Texture uniform. *Weathered fractures at 68.2' (horizontal, and 71.9' (60°).* Fresh and sound.
El. -73.7

FD-1 (See plan sheet 1)
17 June 1957
El. 3±

0	PT	Salt Marsh roots and SILT
	SP-SM	Brown, slightly silty, med. SAND
8		
13	ML	Gray, very fine sandy, SILT
14		
10		

El. -22±

FD-7
3 July 1957
El. 3±

	SM	Dk. brown, salt marsh sod
5		Brown, silty, medium SAND
45	GP-GM	Grayish-brown, silty, sandy GRAVEL
65		Grayish-brown, silty, sandy GRAVEL (Till-Like Material in part)

El. -15±
GRANITE-GNEISS. Light gray, flecked with hornblende and biotite. Fine-grained, showing slight gneissic foliation with variable dip. Biotite concentrations suggest possible schist assimilation. Occasional phlogopite concentrations. The largest, at 19', shows partial decomposition in low-angle fracture. Moderately fresh and sound throughout. Weathered low-angle fracture at 22'. Feldspar concentration at 25'. Light weathering still evident at bottom of core.
El. -28±

FD-6
28 June 1957
El. 4±

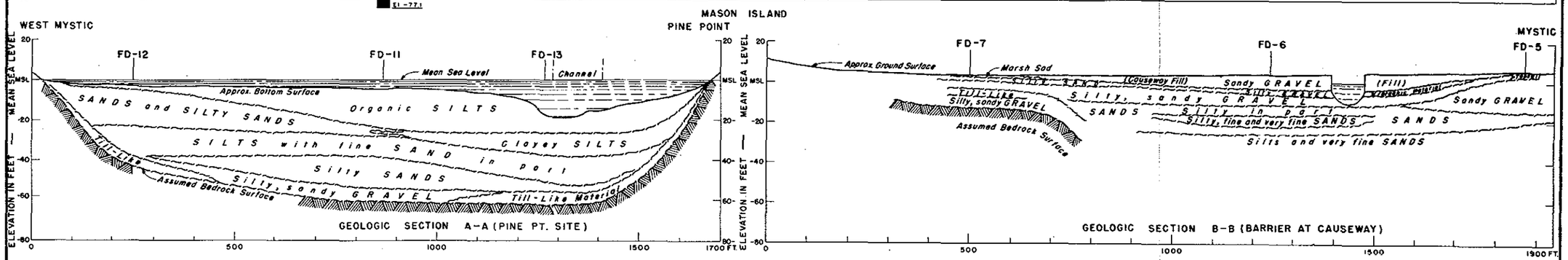
3±		Blacktop
25	GP	Tan, sandy GRAVEL (Fill)
	GM	Dk. brown, org. silty GRAVEL
12	GP-GM	Dark brown, organic, silty sandy GRAVEL
99		Gray, slightly silty, med SAND
28	SP-SM	Gray, silty, fine to very fine SAND
16	SP	Tan, med to fine SAND
8		
	ML	Tan, very fine sandy, SILT
9		

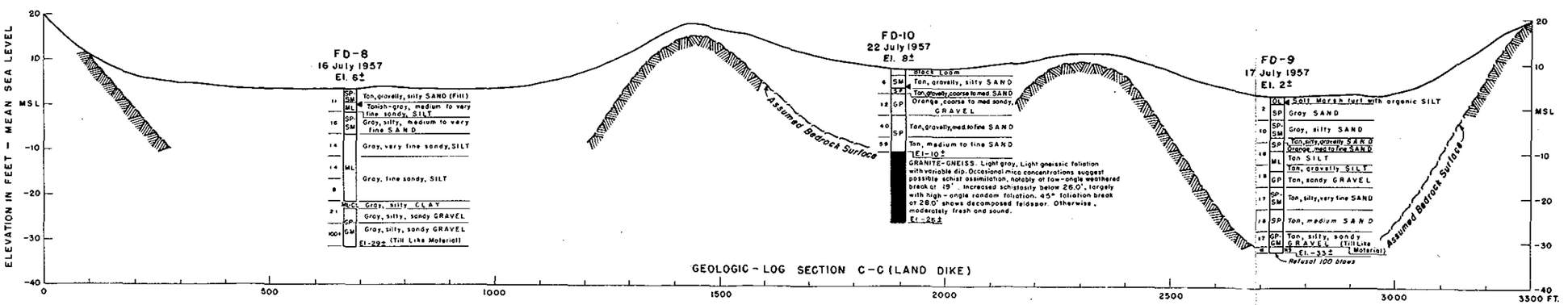
El. -36±

FD-5
24 June 1957
El. 5±

		Topsoil
3		
47		Tan, sandy GRAVEL
	GP	
20		
20		
	SP	Tan SAND
6		
	SP-SM	Grayish tan, silty, very fine SAND
7		

El. -25±





NOTE

Subsurface water levels in the explorations may be subject to tidal fluctuation

LEGEND FOR GRAPHIC LOGS

FD-16 Foundation Test Boring and number
12 Oct. 1956 Date exploration completed
El. -9.2 M.S.L. elevation of ground surface at time of exploration.
Subsurface water level in boring at time of exploration.
SC Group letter symbol according to Unified Soil Classification System
NR No Recovery or unsatisfactory soil samples recovered
NS Not Sampled (Core-drilled, blasted and/or wash bored)
Blows per foot of penetration considered most representative, usually within a 5-foot sample drive using a 350 pound hammer *with a free fall of about 18" on a 2.5" O.D. or 3.0" O.D. size sample* spoon equipped with beveled and sharpened drive shoe.
El. -20.8 Elevation of bedrock surface
Rock core recovery 90-100%
El. -26.0 Elevation at bottom of exploration

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
C.G.H.	R.L.M.	R.C.G.

SUBMITTED: HEAD, SURVEY SECTION
PROJECT ENGINEER: C.E. Wentworth
APPROVAL RECOMMENDED: Chief, Foundation & Materials Branch
APPROVED: Chief, Engineering Division

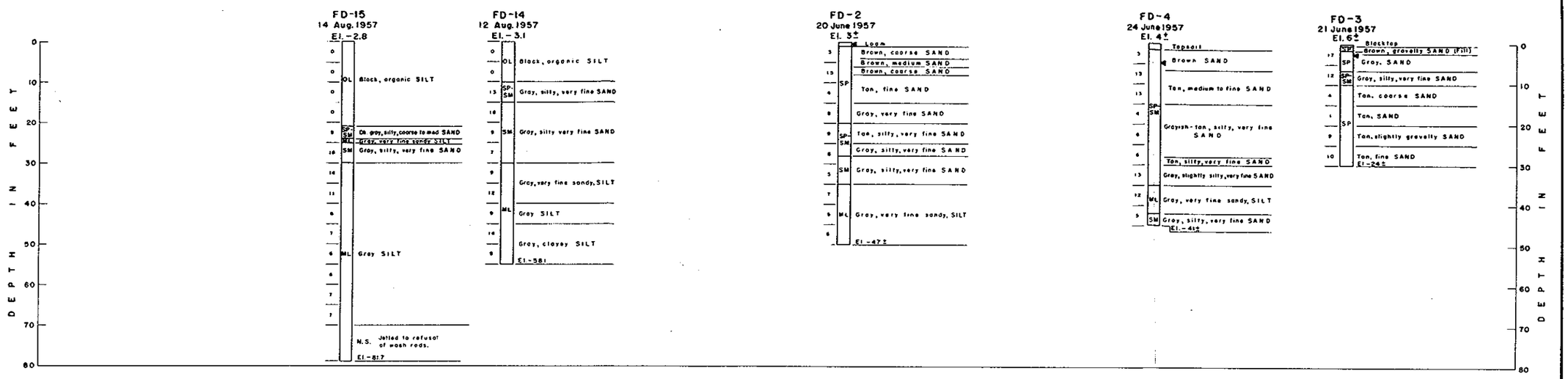
HURRICANE SURVEY
MYSTIC, CONNECTICUT
GEOLOGIC SECTIONS AND
RECORD OF EXPLORATIONS NO. 2
DATE MAY 1960

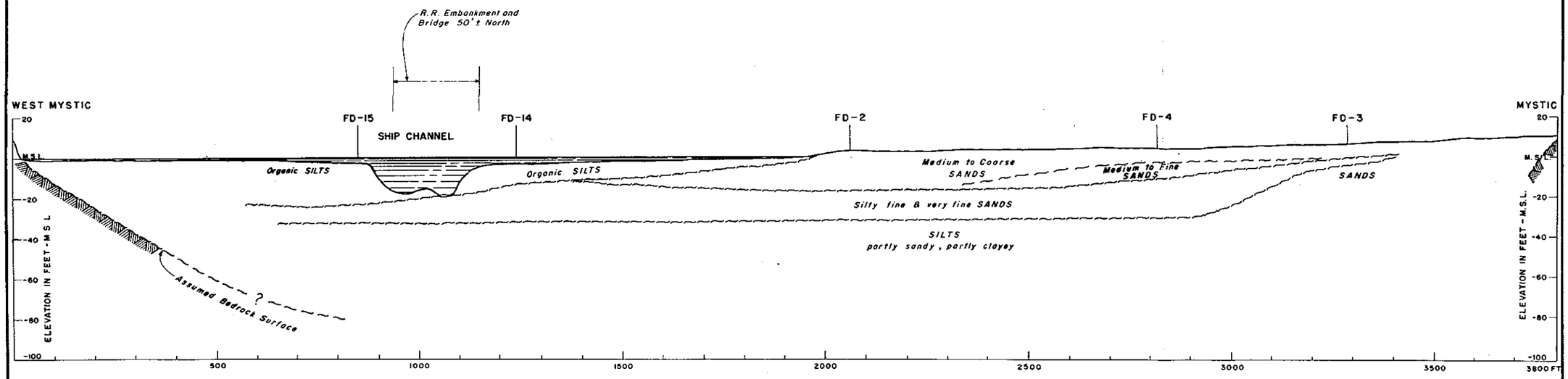
TO ACCOMPANY REPORT
DATED 15 JULY 1960

SCALE: AS SHOWN
DRAWING NUMBER
MYC-2-1002
SHEET 3 OF 4

PLATE D-3

CORPS OF ENGINEERS — U. S. ARMY





GEOLOGIC SECTION D-D

NOTE

Subsurface water levels in the explorations may be subject to tidal fluctuation.

LEGEND FOR GRAPHIC LOGS

FD-17 Foundation Test Boring and number
12 Oct. 1956 Date exploration completed.
El. -9.2 M.S.L. elevation of ground surface at time of exploration.
Subsurface water level in boring at time of exploration.
SC Group letter symbol according to Unified Soil Classification System.
NR No Recovery or unsatisfactory soil samples recovered.
NS Not Sampled (Core-drilled, blasted and/or wash bored)
56 Blows per foot of penetration considered most representative, usually within a 5-foot sample drive using a 350 pound hammer with a free fall of about 18" on a 2.5"O.D. or 3.0"O.D. size sample spoon equipped with beveled and sharpened drive shoe.
El. -20.8 Elevation at botton of exploration.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
CGH	RLM	RCG

SUBMITTED: Chief, Geology Section
PROJECT ENGINEER: C.F. Wilcoxholm
APPROVAL RECOMMENDED: R.G. Sewell
CHIEF, FDN. & MATLS. BRANCH
APPROVED: W. J. Turkel
CHIEF, ENGINEERING DIVISION

HURRICANE SURVEY
MYSTIC, CONNECTICUT
GEOLOGIC SECTION AND RECORD OF EXPLORATIONS NO. 3

DATE: MAY 1960
TO ACCOMPANY REPORT
DATED 15 JULY 1960
SCALE: AS SHOWN
DRAWING NUMBER: MYC-2-1003
SHEET 4 OF 4

PLATE D-4

APPENDIX E

DESIGN STUDIES AND COST ESTIMATES

APPENDIX E

DESIGN STUDIES AND COST ESTIMATES

INTRODUCTION

E-1. The design features and cost estimates for the recommended plan of hurricane protection for Mystic, Connecticut, consisting of the main barrier, barrier at causeway, and related land dikes, are presented in this appendix. The principal features of the plan are shown on Plates E-1 through E-3.

SURVEYS AND EXPLORATIONS

E-2. Both design and cost estimates for the selected plan are based on recent subsurface investigation and field reconnaissance. Terrain and land features were evaluated from Army Map Service Sheets 6666 IV NW and SW, scale 1:25000; U.S. Coast and Geodetic Survey Chart No. 358; and from aerial photographs flown by the U.S. Air Force and the Department of Agriculture.

Subsurface investigations, described in Appendix D, included a total of 18 drive sample borings and 10 hand probings.

DESIGN CRITERIA

E-3. The structures have been designed for protection against a Standard Project Hurricane flood. Both the design criteria and the selected top elevations are shown in Table E-1, below. Appendix B contains further details of design tidal flood and design waves.

The design of structures has followed published standards of the Office of the Chief of Engineers and Beach Erosion Board. The rock protection for the barriers is based on general criteria developed by the Waterways Experiment Station, recognizing that final design studies could require somewhat heavier stone protection without appreciable change in the overall cost of the project.

TABLE E-1

DESIGN CRITERIA AND SELECTED TOP ELEVATION
SIXPENNY ISLAND

Design surge stillwater elevation (feet above m.s.l.)	14.9
Maximum wave height (feet)	3.3
Top elevation of exposed barriers (feet above m.s.l.)	16.5
Top elevation of land dikes (feet above m.s.l.)	15.5

SELECTED PLAN OF PROTECTION (SIXPENNY ISLAND PLAN)

E-4. DESCRIPTION OF PLAN

a. General. The selected plan of protection (see Plate E-1) consists of a 3,200-foot main barrier crossing Mystic Harbor at the northern end of Sixpenny Island from high ground on the west to Mason Island on the east; a barrier at the Causeway to Mason Island with a concrete wall tying into high ground at the west; and a series of earth dikes crossing lowland on Mason Island and in the area east of Mystic. Included in the plan of improvements are the following structures:

(1) A gated navigation opening of 75 feet clear width, centered on the navigation channel at the main barrier.

(2) Two stoplog structures, one highway and one railroad, approximately 6.5 feet high by 50 feet wide.

(3) A stoplogged small boat opening, 12.0 feet wide at the causeway barrier.

The alignment and location of all structures are shown on Plates E-1 and E-2.

b. Main Barrier. The main barrier would be of earth-fill, rock-faced construction with a top elevation of 16.5 feet above m.s.l., and a paved top width of 10 feet, with turn-arounds at the abutments. The embankment design would provide for displacement of the organic silt. See Plates E-1 and E-2 for details.

(1) The navigation opening, with clear width of 75 feet, would have overall width of 84 feet and a depth of 17.2 feet below m.s.l.

The gate would be of fabricated steel of the lift-up type, arranged in vertical panels, open hinged at a bottom sill and locked together and supported at the top by a removable beam for ease in dismantling for maintenance. For details of the gate see Plate E-3. The gate would be operated by a tainter type hoisting system housed at the abutments. The machinery would be synchronized for control from either house.

c. Barrier at Causeway. The causeway barrier would be similar in design to the main barrier. For details see Plates E-1 and E-2.

(1) The small boat opening at the causeway bridge would be provided with a 12.0-foot wide by 22.5-foot high stoplog structure. Details of the small boat opening are shown on Plate E-3.

d. Land Dikes and Wall. Dike "A" would be earth-fill construction, armored on the exposed slope and seeded on the protected slope, with a top elevation of 16.5 feet above mean sea level, and a top width of 10 feet. Dikes "B" and "C" would be of seeded earth-fill construction with a top elevation of 15.5 feet above mean sea level and a top width of 10 feet. The wall at the west end of the causeway barrier is a reinforced concrete "T" type section.

e. Pertinent Data. Information relating to the Sixpenny Island Plan is summarized in Table E-2.

TABLE E-2

PERTINENT DATA
HURRICANE PROTECTION - SIXPENNY ISLAND PLAN
Mystic, Connecticut

Main Barrier

Type: Earth-fill, rock faced (rock toes at gate)	
Top Elevation	16.5 feet, m.s.l.
Length (including gate opening)	3,200 feet
Maximum height (above river bottom)	34.0 feet
Top width	10 feet
Side slopes	
Above m.s.l.	1 on 2.5
Below m.s.l. (1)	1 on 4
Rock toes (at gate)	1 on 1.5

(1) Rock toe construction was utilized in the vicinity of the turn-around and gate structure to allow for steeper underwater slopes.

TABLE E-2 (Cont'd.)

PERTINENT DATA
HURRICANE PROTECTION - SIXPENNY ISLAND PLAN
Mystic, Connecticut

Navigation Gate	
Type: Lift-up, bottom hinged	
Width of Navigation opening	75 feet, clear
Top elevation	16.5 feet, m.s.l.
Sill elevation	-17.2 feet, m.s.l.
Height of gate	35.0 feet
Stoplog Structures	
Type: Railroad	1
Highway	1
Width of opening	50 feet
Height of opening	6.5 feet
Barrier at Causeway	
Type: Earth-fill, rock faced (rock toes at small boat opening)	
Top elevation	16.5 feet, m.s.l.
Length (including small boat opening)	1,950 feet
Maximum height	26 feet
Top width	10 feet
Side slopes	
Above m.s.l.	1 on 2
Below m.s.l.	1 on 4
At Causeway (upstream face)	1 on 1.5
Rock toes (at small boat opening)	1 on 2
Small Boat Opening	
Type: Concrete "U" wall with stoplogs	
Width	12.0 feet
Vertical clearance	5 feet, m.h.w.
Sill elevation	-6.0 feet, m.s.l.
Height of structure	22.5 feet
Land Wall	
Type: Concrete "T" wall	
Top elevation	16.5 feet, m.s.l.
Length	220 feet
Maximum height (above ground)	6.5 feet

TABLE E-2 (Cont'd.)

PERTINENT DATA
HURRICANE PROTECTION - SIXPENNY ISLAND PLAN
Mystic, Connecticut

Land Dikes

Type: Earth-fill, seeded	
Top elevation	
Dike "A"	16.5 feet, m.s.l.
Dike "B" and "C"	15.5 feet, m.s.l.
Length	
Dike "A" (Armored on exposed side)	450 feet
Dike "B"	1,100 feet
Dike "C"	1,100 feet
Maximum height	13 feet
Top width	10 feet
Side slopes	1 on 2

Culvert and Sluice Gate

Type: Concrete, cast in place	
Size	4 x 4 feet
Gate - Cast steel, vertical	1
Operation, manual	

E-5. MODIFICATION TO SEWERAGE AND DRAINAGE FACILITIES

a. Modification to sewer lines. None are required for the Sixpenny Island Plan.

b. Modification to drainage systems. Provisions would be made for drainage and mosquito control in the vicinity of the land dikes.

E-6. LANDS AND DAMAGES

The cost of furnishing necessary lands, easements and rights-of-way, a requirement of local cooperation, has been estimated upon the basis of a field reconnaissance and the application of current market values as determined from a study of a number of recent sales in the area. The estimate includes allowances for the payment of severance damages and acquisition costs. The lands and improvements to be acquired and the land upon which temporary or permanent easements will be secured are summarized below.

Land:

Acquired in fee, for structures	11.3 acres
Construction easements, temporary	14.3 acres
Permanent easements	2.6 acres

E-7. RELOCATIONS

The construction of the Sixpenny Island Plan does not require relocation of highways, railroads or utilities.

E-8. GEOLOGY OF SITE

The geology of the area and the foundation conditions for the protective structures are discussed in Appendix D. The results of the subsurface explorations are shown on Plates D-1 through D-3.

E-9. AVAILABLE MATERIALS

Adequate quarry sites are available nearby for supplying armor stone and bedding stone for the main barrier and the barrier at the causeway. Fill material is available in sufficient quantities to form barrier and dikes. For more detailed information on availability of construction materials within the Mystic area see Appendix D.

E-10. PLAN OF CONSTRUCTION

The construction of the Sixpenny Island Plan would require about two years. The construction schedule, predicated on the erection of the navigation gate structure in the dry by cofferdamming, would be generally as follows:

a. During the first year a bypass channel would be dredged and foundations prepared for the navigation gate structure at the main barrier and at the small boat opening at the causeway barrier. The abutments for the navigation structure would then be constructed and cofferdams formed for both structures. The construction of the navigation gate structure and small boat opening would be completed and the cofferdams removed by the close of the first year.

b. The stoplog structures, land wall, land portion of the barriers and the dikes could be constructed concurrently with the gate structure and small boat opening in the first year.

c. The construction of the main barrier would be initiated to provide access to the navigation structure cofferdam before the close of the first year and be completed in the second year.

BASIS OF ESTIMATES OF FIRST COST AND ANNUAL COSTS

E-11. COST ESTIMATES

The cost of the plan has been estimated on the basis of a design which would provide economical and safe structures. Embankment quantities are based on the typical cross sections and details shown on Plate E-2 and include allowance for settlement.

E-12. UNIT PRICES

Unit prices are based on averages for similar types of projects either constructed, under construction, or under contract in New England and where applicable, similar construction in other parts of the country. Adjustments have been made for the availability and sources of material required. The adopted unit prices, which are on a 1960 price level basis, also reflect adjustments to include minor items of work.

E-13. CONTINGENCIES, ENGINEERING AND OVERHEAD

The estimate includes a 20 percent allowance to cover contingencies. The cost of engineering, design, supervision and administration are estimated lump sums based on knowledge of the site and recent experience. These items of cost for various phases of the plan are as shown in Table E-3.

E-14. LOCAL CONTRIBUTIONS

Local interests would be required to contribute 30 percent of the first cost of the project (less costs for preauthorization survey studies and navigation aids), comprising (1) a cash contribution to the United States, presently estimated at $549,000, and (2) lands, easements, and relocations necessary for the construction of the project, presently estimated at $89,000.

E-15. ANNUAL COSTS

The estimate for annual charges is based on 2.5 percent interest on the Federal investment cost and 3.0 percent interest on the local investment cost and amortization of the investment over a period of 50 years. The total investment, Federal plus non-Federal, equals the first cost plus 2.5 percent interest on the Federal first cost and 3.0 percent interest on non-Federal first cost for one year or one-half of the estimated construction period of two years. An allowance of $200 for the loss of taxes on lands is included in the annual charges. Costs of maintenance and operation of the project are based on a knowledge of the site and costs of similar projects.

FIRST COSTS AND ANNUAL COSTS

E-16. FIRST COSTS

The first cost of the Sixpenny Island Plan is estimated at $2,128,000, of which $1,490,000 would be borne by the United States. Local interests would contribute in cash $549,000 and provide all lands, easements and rights-of-way necessary for the construction of the project at an estimated cost of $89,000. The costs of the individual structures are shown in detail in Table E-3. Detailed breakdowns of the estimates, by principal features of the work, and by quantities and unit prices, are also shown in Table E-3.

TABLE E-3

ESTIMATED FIRST COSTS
(1960 Price Level)
HURRICANE PROTECTION - SIXPENNY ISLAND PLAN
Mystic, Connecticut

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
MAIN BARRIER				
Earth Excavation, Channel	6,000	c.y.	2.00	$ 12,000
Earth Fill	115,000	c.y.	1.00	115,000
Rock Fill - Armor Stone	16,000	c.y.	5.00	80,000
Rock Fill - Bedding Stone	8,000	c.y.	4.00	32,000
Rock Fill - Riprap	6,400	c.y.	4.00	26,000
Rock Fill - Dumped Rock	11,000	c.y.	4.00	44,000
Gravel	12,000	c.y.	2.50	30,000
Paving	3,000	s.y.	2.00	6,000
Approach Ramps	1	Job	L.S.	2,000
Stoplog Structure	1	Job	L.S.	8,000
Navigation Gate Structure				
Cofferdam and Unwatering	1	Job	L.S.	294,000
Earth Excavation	6,500	c.y.	2.00	13,000
Concrete, Reinforced	1,140	c.y.	65.00	74,000
Concrete, Mass	825	c.y.	35.00	29,000
Concrete, Tremie	1,455	c.y.	25.00	36,000
Steel "H" Piles	8,500	L.F.	9.00	77,000
Steel Sheet Pile Cutoff	840	S.F.	4.00	3,000
Gate and Equipment	1	Job	L.S.	301,000
Fender Piles and Dolphins	1	Job	L.S.	24,000
Gravel Fill	1,300	c.y.	2.50	3,000
				$1,209,000
Contingencies				242,000
Total Cost - MAIN BARRIER				$1,451,000
BARRIER AT CAUSEWAY				
Earth Fill	33,000	c.y.	1.00	33,000
Rock Fill - Armor Stone	8,300	c.y.	5.00	41,000
Rock Fill - Bedding Stone	5,200	c.y.	4.00	21,000
Rock Fill, Riprap	3,000	c.y.	4.00	12,000
Gravel	7,000	c.y.	2.50	18,000
Wall Concrete-Reinforced	1	Job	L.S.	14,000
Stoplog Structure	1	Job	L.S.	8,000
Small Boat Opening				
Cofferdam and Unwatering	1	Job	L.S.	11,000
Concrete, Reinforced	292	c.y.	65.00	19,000
Stoplogs	1	Job	L.S.	5,000
				$ 182,000
Contingencies				36,000
Total Cost - BARRIER AT CAUSEWAY				$ 218,000

TABLE E-3 (Cont'd.)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount
LAND DIKES				
Land Dike "A"	1	Job	L.S.	$ 20,000
Land Dike "B"	1	Job	L.S.	10,000
Land Dike "C"	1	Job	L.S.	9,000
				$ 39,000
Contingencies				8,000
Total Cost - LAND DIKES				$ 47,000
ENGINEERING AND DESIGN				172,000
SUPERVISION AND ADMINISTRATION				151,000
TOTAL COST - SIXPENNY ISLAND PLAN				$ 2,039,000
LANDS AND DAMAGES				
Land (in fee)	11.3	Acres	L.S.	$ 26,400
Permanent Easements	2.6	Acres	L.S.	2,500
Temporary Easements	14.3	Acres	L.S.	6,600
Severance Damage	1	Job	L.S.	10,000
Subtotal				$ 45,500
Contingencies				9,500
				55,000
Acquisition Cost				34,000
TOTAL COSTS - LANDS AND DAMAGES				$ 89,000
SUMMARY				
SIXPENNY ISLAND PLAN				$ 2,039,000
Lands and Damages				89,000
SUBTOTAL - FIRST COST				$ 2,128,000
Navigation Aids (To be installed by U.S. Coast Guard)				10,000
Preauthorization survey studies				25,000
Estimated First Cost to U.S.				$ 1,490,000
Estimated First Cost to Local Interests				638,000(1)

(1) Includes estimated costs of $89,000 for lands and damages, and a local cash contribution presently estimated at $549,000 to the United States. This local cash contribution when added to the estimated costs of lands and damages represents a local interests share of 30 percent of the first cost of the project.

E-17. ANNUAL COSTS

The total annual costs for the Sixpenny Island Plan amount to an estimated $97,000. Of this amount $56,000 represents Federal annual costs and $41,000 non-Federal. The determination of annual costs is shown in Table E-4.

TABLE E-4

ESTIMATED ANNUAL COSTS
(1960 Price Level)
HURRICANE PROTECTION - SIXPENNY ISLAND PLAN
Mystic, Connecticut

Federal Investment Cost		
Total Federal First Cost		$1,525,000(1)
Interest during Construction		38,000
Total Federal Investment Cost		$1,563,000
Federal Annual Costs		
Interest on Investment, 2.5%		39,000
Amortization, 1.026%		16,000
Maintenance and Operation		
Navigation Aids (2)		1,000
Total Federal Annual Costs		$ 56,000
Non-Federal Investment Cost		
Total Non-Federal First Cost		638,000
Interest during Construction		19,000
Total Non-Federal Investment Cost		$ 657,000
Non-Federal Annual Costs		
Interest on Investment, 3.0%		$ 20,000
Amortization, 0.886%		6,000
Major Replacements, Navigation Gate Aux. Equip.		1,700
Maintenance and Operation		
Salaries	$2,500	
Supplies	500	
Embankment and General	2,800	
Concrete Features	300	
Navigation Gate and Accessories	5,400	
Stoplog Structures	1,600	13,100
Estimated Tax Losses		200

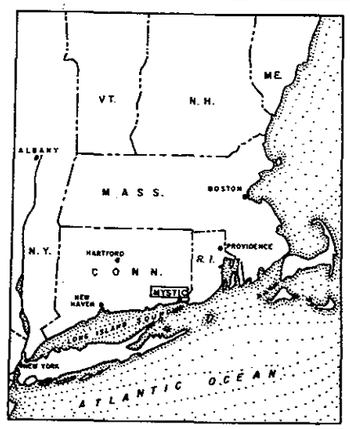
(1) Includes $25,000 for preauthorization survey studies and $10,000 for navigation aids.
(2) To be maintained and operated by the U.S. Coast Guard.

TABLE E-4 (Cont'd.)

Total Non-Federal Annual Costs	$41,000
TOTAL ANNUAL COSTS	97,000

CORPS OF ENGINEERS

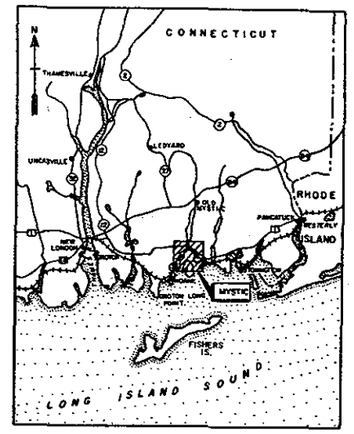
U S ARMY



LOCATION MAP

SCALE IN MILES

25 0 25 50



VICINITY MAP

SCALE IN MILES

0 1 2 3 4 5 6

PLAN

SCALE IN FEET

600 0 600 1200

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM MASS.

DES. BY H.E.A.	DR. BY W.J.C.	CK. BY C.E.W.

SUBMITTED: G.B. Miller, CHIEF, HURRICANE UNIT NO. 1

PROJECT ENGINEER: L.C. Wentworth

HURRICANE SURVEY

MYSTIC, CONNECTICUT

SIXPENNY ISLAND PROTECTION PLAN

GENERAL PLAN

APPROVAL RECOMMENDED: L.L. Langford, CHIEF, PLANNING & REPORTS BRANCH

APPROVED: Lem Willis, CHIEF, ENGINEERING DIVISION

DATE MAY 1960

TO ACCOMPANY REPORT DATED 15 JULY 1960

SCALE: AS SHOWN

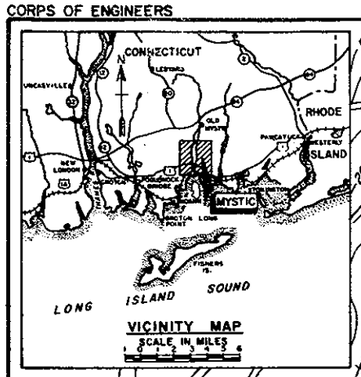
DRAWING NUMBER MYC-1-1001

SHEET OF

PLATE E-1

CORPS OF ENGINEERS

U. S. ARMY



MYSTIC HARBOR

MURPHY POINT

PUBLIC BEACH

WILLOW PT.

9 ACRE BOAT ANCHORAGE

GROTON

STONINGTON

PINE PT.

SPENCE PT.

EXISTING 12' NAVIGATION CHANNEL

MASON ISLAND

SIXPENNY ISLAND

CLAM PT.

SEA GULL ST.

N.Y.N.H. & H. R.R.

BLACK HILL ROAD

CEDAR POINT ROAD

WEST APPROACH

STOP LOG

FENDER PILES AND DOLPHINS

EAST APPROACH

MAIN BARRIER

75' GATED NAVIGATION OPENING

LAND DIKE "A"

CULVERT

RAMP

SMALL BOAT OPENING

BARRIER AT CAUSEWAY

CONCRETE LAND WALL

STOP LOG

LAND DIKE "B"

LAND DIKE "C"

PLAN
SCALE IN FEET
0 300 600 900

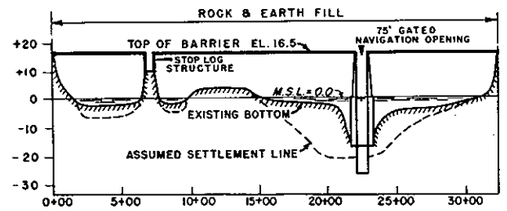
SECTION A-A
SCALE: 1" = 10'
0 10 20 30 FT.

SECTION E-E
(TYPICAL DIKE)
SCALE: 1" = 10'

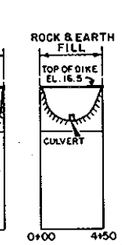
SECTION D-D
SCALE: 1" = 10'

SECTION C-C
SCALE: 1" = 10'

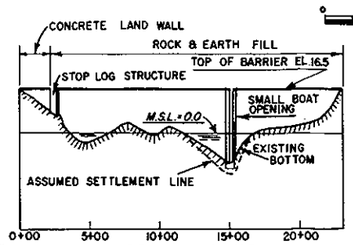
SECTION B-B
NOT TO SCALE



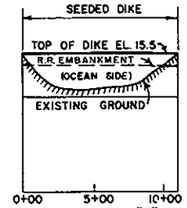
MAIN BARRIER



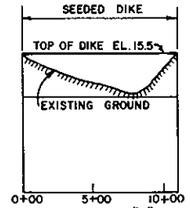
LAND DIKE "A"



BARRIER AT CAUSEWAY



LAND DIKE "B"



LAND DIKE "C"

PROFILE ALONG ℄ OF BARRIERS AND DIKES

HOR. 0 400 800 1200
VERT. 0 20 40 60
SCALE IN FEET

NOTE:
Elevations are in feet and are referred to Mean Sea Level Datum.
Soundings are in feet and are referred to Mean Low Water Datum.
Soundings are taken from U.S.C.&G.S. CHART No. 358.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY H.E.A. | DR. BY W.J.C. | CK. BY C.E.W.

SUBMITTED: C. E. Miller, CHIEF, HURRICANE UNIT NO.1

PROJECT ENGINEER: C. E. Wentworth

APPROVED RECOMMENDED: [illegible], CHIEF, PLANNING & REPORTS BRANCH

APPROVED: [illegible], CHIEF, ENGINEERING DIVISION

DATE: MAY 1960

SCALE: AS SHOWN

TO ACCOMPANY REPORT DATED 15 JULY 1960

DRAWING NUMBER: NYC-1-1002

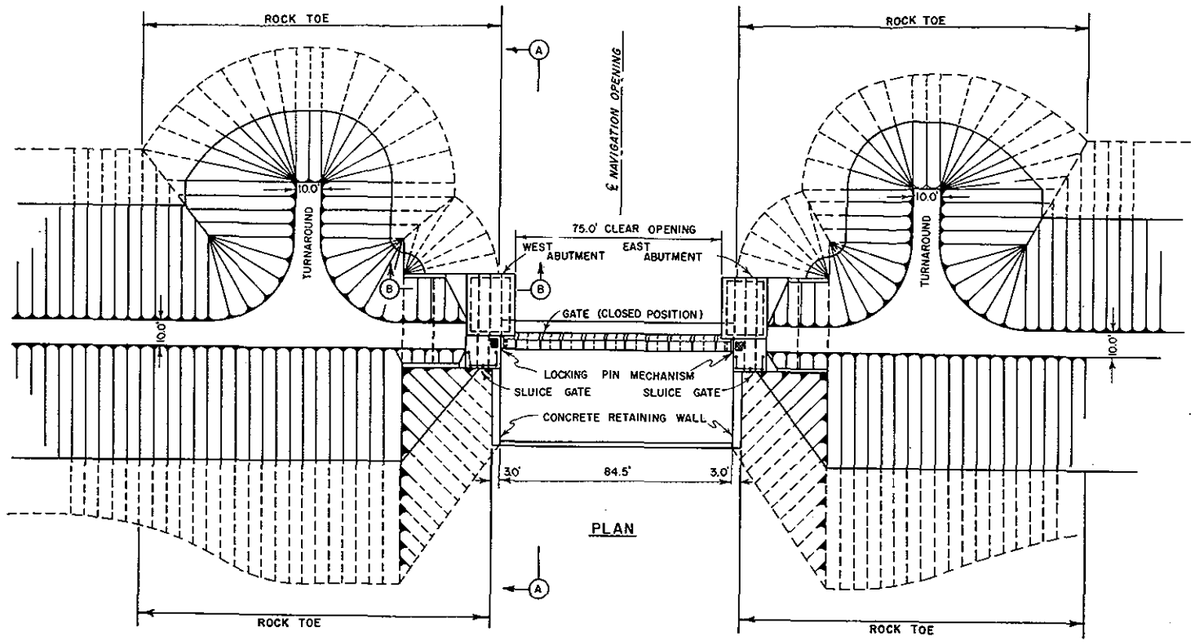
SHEET OF

HURRICANE SURVEY
MYSTIC CONNECTICUT
SIXPENNY ISLAND BARRIER PLAN
PLAN, PROFILE & SECTIONS

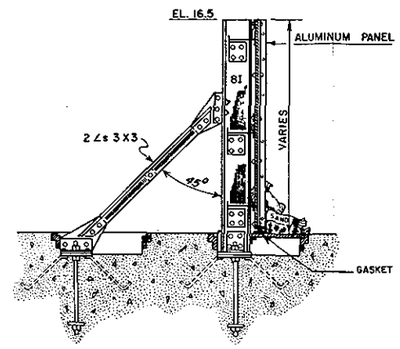
PLATE E-2

CORPS OF ENGINEERS

U. S. ARMY

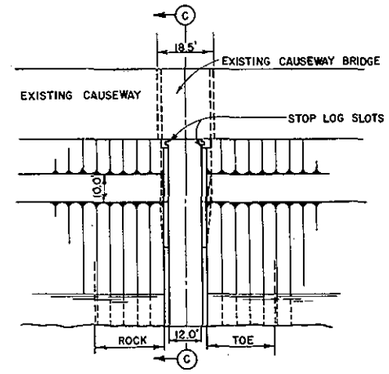


PLAN

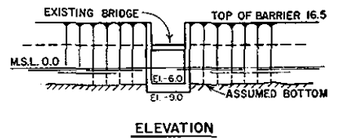


TYPICAL STOP LOG STRUCTURE

NOT TO SCALE



PLAN

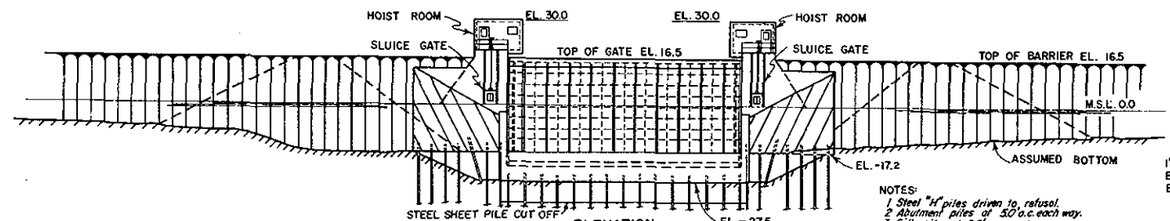


ELEVATION

SMALL BOAT OPENING

SCALE IN FEET

0 20 40 60



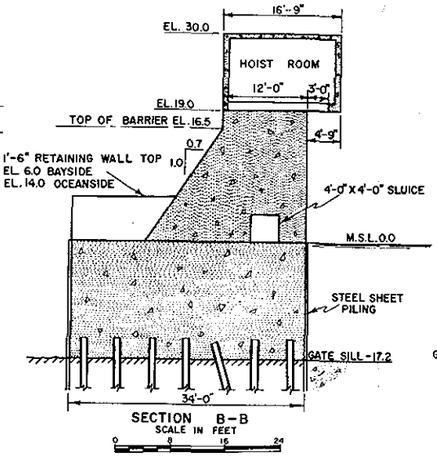
NOTES:
1 Steel "H" piles driven to refusal.
2 Abutment piles at 5.0' o.c. each way.
3 Sill piles at 6.0' o.c. each way.

ELEVATION

NAVIGATION GATE

SCALE IN FEET

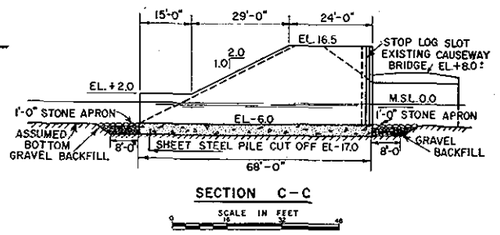
0 20 40 60



SECTION B-B

SCALE IN FEET

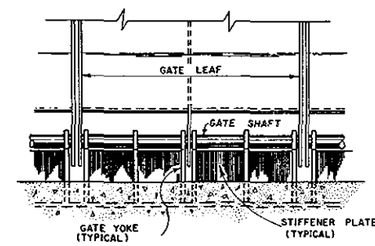
0 8 16 24



SECTION C-C

SCALE IN FEET

0 16 32 48



GATE HINGE DETAIL

SCALE IN FEET

0 2 4 6

SECTION A-A

SCALE IN FEET

0 8 16 24

NOTE:

Elevations are in feet and are referred to Mean Sea Level Datum.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
H.E.A.	R.M.	C.E.W.

SUBMITTED: Joseph P. Cleary
CHIEF, HURRICANE UNIT, NED

PROJECT ENGINEER: C.E. Woodworth

APPROVAL RECOMMENDED: Robert W. Whitman
CHIEF, PLANNING BRANCH

APPROVED: [signature]
CHIEF, ENGINEERING DIVISION

DATE: MAY 1960

HURRICANE SURVEY

MYSTIC CONNECTICUT

NAVIGATION GATE AND APPURTENTANT WORKS

TO ACCOMPANY REPORT
DATED 15 JULY 1960

SCALE AS SHOWN

DRAWING NUMBER
NYC-1-1003

SHEET of

PLATE E-3

APPENDIX F

PUBLIC HEARING AND VIEWS OF OTHER AGENCIES

APPENDIX F

PUBLIC HEARING AND VIEWS OF OTHER AGENCIES

F-1. GENERAL

This appendix presents a digest of the public hearing and also includes available letters and statements indicating the views of other agencies and individuals, not represented at the hearing, on the plans of protection.

F-2. DIGEST OF PUBLIC HEARING

A public hearing was held by the Division Engineer in Mystic, Connecticut on 23 September 1957 to give all interested parties an opportunity to express their views concerning the character and extent of hurricane protection desired and the need and advisability of its execution. Information was presented at the beginning of the hearing on preliminary studies by the Corps of Engineers including alternative plans and cost estimates. A digest of the hearing is attached together with abstracts of correspondence from local interests pertaining to the recommended plan of protection.

F-3. LETTERS OF COMMENT

a. U. S. Public Health Service - letter signed by Mr. Lester M. Klashman, dated 2 May 1958.

b. U. S. Fish and Wildlife Service - letters signed by Mr. E. W. Bailey, Acting Regional Director, and Mr. D. R. Gascoyne, Regional Director, dated 3 December 1957 and 21 February 1958, respectively.

c. State of Connecticut, Department of Health - letter signed by Mr. Julius Elston, Chief, Division of Mosquito Control, dated 28 May 1958.

F-4. LOCAL COOPERATION

a. The Honorable Abraham Ribicoff, Governor, State of Connecticut. Letter dated 27 August 1958.

b. Mr. David M. Johnstone, First Selectman, Town of Stonington, and former senator, Twentieth District, State of Connecticut. Letters dated 4 September and 22 April 1958 with inclosure (letter from Mystic Fire District, dated 21 April 1958, signed by Walter H. Prescott); letter dated 17 June 1960.

c. Mr. John J. Curry, Chief Engineer, Water Resources Commission, State of Connecticut. Letter dated 21 February 1958.

d. The Honorable George E. Kinmouth, Mayor of Groton. Letters dated 2 September and 14 April 1958.

DIGEST OF PUBLIC HEARING, MYSTIC, CONNECTICUT - 23 SEPTEMBER 1957

Speaker	Interest Represented	Protection Desired	Reasons Advanced and Other Remarks
Mr. John J. Curry State Water Resources Commission	Connecticut Water Resources Commission	Reserved opinion until further studies were made. (See letter incl.)	Commented that outer projects might obstruct views of property owners. Indicated that State takes "an active interest" in cooperation on flood projects and beach erosion.
Capt. Israel M. Jacobs	Atlantic States Marine Fisheries Commission and Southern New England Fishermen's Association		Suggested calling a Town meeting to determine how far the people would go in cost sharing.
Mr. Aldo J. Santin Member of Rivers and Harbors Committee and Selectman, Town of Groton	Individual	Expressed belief that the Town of Groton is definitely interested and in favor of the suggested protective measures.	Requested further study of the protective measures with particular emphasis on cost sharing between Federal, State and local interests.
Mr. Evert A. Engstrom	First Selectman, Town of Stonington		Present as an observer only.
Mr. Leon E. Benoit Chairman, Mystic Fire District and Chairman of Volunteer River & Harbor Committee	Individual	Favored Railroad Embankment Plan but Sixpenny Island Plan would be acceptable.	Requested that Army Engineers determine the most beneficial plan for the area. Subsequent to discussion of barrier effects on pollution, he stated that Mr. Wise (Director, Connecticut Water Resources Commission) "has declared that in 1959 Mystic will have a sewage system."

Mr. James H. Allyn	Representative from Town of Stonington		Concerned with cost of the suggested plans and effect on pollution. Raised question as to adequacy of 75-foot opening in barrier and effect increased current would have on navigation.
Mr. Fred A. Crothers	Individual		Suggested extent of protection should be the main concern rather than just the minimum cost.
Mr. Otto E. Liebig	Individual	Favored Railroad Embankment Plan but suggested it should be extended about 2,000 feet east along the railroad embankment.	Suggested this extension would provide protection equivalent to outer barrier.
Mr. Carroll L. Moore	Individual	Favored protection	Expressed concern as to the effect barriers would have on pollution; feared pollution would affect clamming in that area; questioned adequacy of 75-foot navigation opening.
Mr. Frank J. Bradley	Individual	Favored Pine Point Plan	Stated 75% of the sewage went into cesspools, was pumped out and hauled away. Expressed concern that boats might be left outside after gates were closed during a hurricane.
*Mr. John G. Lee	Individual	Favored Sixpenny Island Plan if the cost was substantially the same as the Railroad Embankment Plan. If not, then would prefer the lower cost project.	Pine Point Plan would take in part of his property; stated he and his wife would interpose no objection if that was the plan preferred by local interests.

Mr. Clarence Trudell	Individual	Favored Pine Point Plan and Sixpenny Island Plan over Railroad Embankment Plan.	Expressed belief that the more extensive plan of hurricane protection would provide greater protection for vessels, and allow for growth of the area.
Mr. William Dodge	Individual	Suggested a lower barrier.	Expressed concern that too high a barrier might be a detriment to the building industry.
Mr. Elmer J. Travers Meteorologist, U.S. Weather Bureau Sta., New Haven, Conn.	U. S. Weather Bureau		Commented on Weather Bureau warnings and complex meteorologic conditions in connection with hurricanes.
Mr. David K. Fentress	Individual		Raised question as to the amount of build-up in front of the barriers.
Mr. Francis R. Fain	Individual	Favored Railroad Embankment Plan	Requested that consideration be given to the number of residences rather than the acreage protected.
Mr. Clinton H. Durpee	Individual	Favored Sixpenny Island Plan	Suggested that the plan which would give protection to the largest area and greatest number of people should be given the most consideration.
Mr. L. Emmett Holt	Individual		Asked questions on the amount of damage that would have been prevented due to saltwater flooding in 1938 and August 1954 if the dikes had been there.

Mr. Cameron Winslow	Individual	Requested clarification on effectiveness of a rock fill barrier; would it hold the water back or serve as a wave action deterrent only. Questioned the reliability of electricity if used for closing the gates at the time of a hurricane.
Mr. B. F. Rathbone	Individual	Asked questions on the operational cost of maintenance for the gates

Mr. James H. Allyn requested a "show of hands" in order that the consensus of opinion might be indicated as people in that area were "diffident about getting up and speaking in public". The vote indicated (1) No one opposed the suggested protective measures; (2) 23 people favored the "Railroad Embankment Plan"; (3) Six favored the "Pine Point Plan"; (4) 17 favored the "Sixpenny Island Plan"; and (5) one indicated he preferred another plan but did not state the plan.

*After the hearing was adjourned, Mr. Lee handed a typewritten letter to a member of the staff representing the New England Division, Corps of Engineers. He did not wish to have the letter read into the record but felt it expressed more clearly what he had said during the hearing. This letter is included as subsequent correspondence.

LETTERS AND STATEMENTS FORWARDED TO THE DIVISION ENGINEER, NEW ENGLAND DIVISION

RELATING TO THE PLANS OF PROTECTION SUGGESTED AT THE PUBLIC HEARING

Signed by	Interest Represented	Date of Letter and Remarks
Mr. Fred Garbarino	Garbarino Bros.	September 25, 1957. Letter favoring the Sixpenny Island location with a second choice of the Railroad Embankment location. This choice is based on a proposal by the Garbarino Brothers for a marina on Mason Island.
Mr. Francis R. Fain	Individual	September 26, 1957. Letter expressing a definite preference for the Railroad Embankment Plan due to personal reasons. Value of his property would be decreased by 1/3 to 1/2 as a result of the other protective measures.

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE
Region II
42 Broadway
New York 4, N.Y.

May 2, 1958

Refer to: 24:SE

Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Attention: Lt. Colonel Miles L. Wachendorf
Assistant Division Engineer for Civil Works

Dear Sir:

Reference is made to your letter of February 17, 1958 requesting our comments on the proposed barriers to provide protection against hurricane tidal flooding in Mystic, Towns of Groton and Stonington, Connecticut. The proposed structures are shown on Corps of Engineers plan entitled "Hurricane Survey, Mystic Harbor, Connecticut Tidal Barrier Studies, Alternative Plans" dated April 1957.

It appears that one of the barriers will be located seaward of a proposed sewage treatment plant to be constructed by the Town of Groton, Connecticut. We understand that an engineering study of this proposed plant is now being made by the engineering firm of Metcalf and Eddy.

If the treatment plant should be constructed prior to construction of the barrier, consideration should be given to pollution of the bay from the discharge of the outfall due to confining influence of the barrier. It might be necessary for the final barrier plans to include an extension of the outfall to the seaward side.

With reference to the effect of the proposed barrier on mosquito breeding places, it is noted that the west end of the barrier from the mainland on the west to Pine Point on Mason's Island is to be constructed over one of the salt marshes maintained by the Division of Mosquito Control of the Connecticut State Department of Health. Such construction will of necessity result in cutting off of some salt marsh drainage ditches from tidal circulation.

It is recommended that all contracts for the construction of rock-and-earth filled barriers over ditched and drained salt marsh areas include clean up clauses which call for restoration of drainage to the approval of the Connecticut State Department of Health, Division of Mosquito Control.

Division Engineer--5/2/58
Attn: Lt. Colonel Miles L. Wachendorf

It is suggested that all final payments to such contractors be withheld until such approval is obtained.

It is suggested that final plans for the tidal barrier be reviewed with Mr. Warren J. Scott, Chief, Sanitary Engineering Services, Connecticut State Department of Health and Mr. William S. Wise, Director, Connecticut State Water Resources Commission.

For the Regional Engineer.

Sincerely yours,

L. M. Klashman

Lester M. Klashman
Acting Assistant Regional Engineer
Water Supply & Water Pollution Control

REGION 5

NEW ENGLAND STATES
NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
WEST VIRGINIA

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
OFFICE OF REGIONAL DIRECTOR
BLAKE BUILDING
BOSTON 11, MASSACHUSETTS

IN REPLY REFER TO:

December 3, 1957

Your File No.
NEDGW

Division Engineer
New England Division
U. S. Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:

Reference is made to Lt. Colonel Wachendorf's letter of November 14, 1957 concerning the proposed hurricane protection plan for the harbor at Mystic, Connecticut.

None of the three alternate plans for hurricane protection at Mystic will seriously alter the present habitat for fish or wildlife. There is no commercial fishery or shell fishery in the area to be protected and the major sport fishing grounds are outside the harbor area. The Six Penny Island Plan, (No. 4A), if constructed, would result in a minor loss of waterfowl habitat.

Our field investigation of this project revealed that the Railroad Embankment Plan, (No. 3), is the choice of the local interests and since losses or benefits to fish and wildlife would be negligible under this plan, no further reports are required.

Sincerely yours,

E. W. Bailey
Acting Regional Director

REGION 5

NEW ENGLAND STATES
NEW YORK
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UNITED STATES
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BUREAU OF SPORT FISHERIES AND WILDLIFE
OFFICE OF REGIONAL DIRECTOR
BLAKE BUILDING
BOSTON 11, MASSACHUSETTS

IN REPLY REFER TO:

February 21, 1958

Division Engineer
New England Division
150 Causeway St.
Boston 14, Mass.

Dear Sir:

On February 14, Colonel Wachendorf reported that Plan 4 for the protection of Mystic, Connecticut against hurricane tidal floods would be the most practical plan.

As indicated in our letter of December 3, 1957, none of the plans proposed for this harbor, including Plan 4, will significantly alter present fish and wildlife habitat.

Sincerely yours,

D N Gascoyne

D. R. Gascoyne
Regional Director

Cr ISSIONER OF HEALTH
STAN H. OSBORN, M.D., C.P.H.

BUREAU OF SANITARY ENGINEERING
WARREN J. SCOTT, S.B.
DIRECTOR

DIVISION OF MOSQUITO CONTROL
JULIUS ELSTON, B.S., M.P.H.
CHIEF

REPLY TO:
P.O. BOX 708
MADISON, CONNECTICUT

STATE OF CONNECTICUT
DEPARTMENT OF HEALTH

May 28, 1958

Mr. John B. McAleer
Chief, Hurricane Unit
Corps of Engineers, U. S. Army
Office of the Division Engineer
150 Causeway Street
Boston 14, Massachusetts

Dear Mr. McAleer:

The plans you sent for hurricane-flood protection at Mystic, Connecticut, have been received.

The west end of the main barrier is to be constructed over one of our state maintained salt marsh areas. Such construction will of necessity result in the cutting off of some salt marsh drainage ditches from tidal circulation. In your letter you state that the report contains the following language:

> "A collector ditch would be provided in the swamp at the west end of the main barrier for drainage and mosquito control."

Lacking any further details, I have no way of knowing whether such a collector ditch would restore drainage adequately.

I suggest that all contracts calling for construction of structures over ditched and drained salt marsh areas include clean up clauses calling for restoration of drainage.

What provision has been made for drainage of the marsh area north of Land Dike B and west of Land Dike C? Land Dike C is at the upper limit of the tidal reach at Wilcox Cove and the marsh above the proposed dike is a fresh water marsh.

Very truly yours,

Julius Elston

JULIUS ELSTON, CHIEF
Division of Mosquito Control

JE/se

ABRAHAM RIBICOFF
GOVERNOR

STATE OF CONNECTICUT
EXECUTIVE CHAMBERS
HARTFORD

August 27, 1958

Brigadier General Alden K. Sibley
New England Division Engineer
Corps of Engineers, U. S. Army
150 Causeway Street
Boston 14, Massachusetts

Dear General Sibley:

This will refer to your letter of August 26 requesting opinion concerning the revised report on the hurricane protection project which is proposed for Mystic, Connecticut.

I have consistently supported sound programs for the protection of the people of Connecticut and their development against damages from floods and hurricanes. Mystic has suffered heavy damage from tidal flooding during past hurricanes and protection against the recurrence of such damages is needed.

At the present time there are no specific State funds available for participating in such projects in accordance with requirements as contained in your letter. However, the executive, legislative and administrative agencies of the State have cooperated and participated in sound projects in the past and now there is no reason to assume that the same policies will not be followed in a sound program for the protection of Mystic when such a project reaches the stage of construction.

Sincerely,

Abe Ribicoff

Governor

smv

Town of Stonington, Conn.

SELECTMEN'S OFFICE, TOWN HALL

Telephone Mystic JEfferson 6-9361

September 4, 1958

U. S. Army Engineer Division
150 Causeway Street
Boston 14, Massachusetts

Gentlemen:

Ref. File: NEDGW
I am replying to your letters of August 22 and 26 regarding an opinion about the willingness and ability of local interests to meet the requirements of cooperation for hurricane tidal-flood protection at Pawcatuck and Mystic, both in the Town of Stonington.

The matter was brought up in a recent meeting of the Board of Selectmen and it is it's opinion that the Town would be unwilling and unable to meet the entire 30% contribution requested of local interests in both cases. However, it is still the Board's opinion that there is willingness on the part of the Town to bear part of the cost of the project as well as its maintenance.

The exact percentage can't be set at this time, and of course, would have a great deal to do with the contribution on the part of the State of Connecticut which from your point of view is part of the 30% contribution of local interests. The State Legislature has not had a State-aid salt water flood protection program before it, although it is anticipated that the next session in January 1959 will have such a request. As far as the Town of Stonington is concerned, it will have to wait for the outcome of this legislation.

Yours very truly,

David M. Johnstone

David M. Johnstone
First Selectman

DMJ:EFC

Town of Stonington, Conn.

SELECTMEN'S OFFICE, TOWN HALL
Telephone Mystic Jefferson 6-9361

April 22, 1958

U. S. Army Engineer Division
Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Attention: Mr. John McAlear.

Gentlemen:

In reply to your letter of April 4, 1958 concerning hurricane flood protection of the Mystic area in the Towns of Groton and Stonington, the Stonington Board of Selectmen has met and believes the plans for the project appear satisfactory and expect that the Town of Stonington will be willing to participate with the State and other local interests on the cost of the project when authorized by Congress.

Enclosed is a letter from the new executive committee of the Mystic Fire District reiterating their interest in the project.

Yours very truly,

David M. Johnstone

David M. Johnstone
First Selectman

DMJ:EFC
Enclosure 1

MYSTIC FIRE DISTRICT

MYSTIC CONNECTICUT

April 21, 1958

Selectmen, Town of Stonington
Town Hall
Stonington, Connecticut

Gentlemen:

The Executive Committee of the Mystic Fire District feels that there is a definite interest in the Survey of the Mystic River Basin for Hurricane protection and would like this interest to go on record. This is a reiteration of the letter sent February 20, 1958 by the former Executive Committee.

Respectfully yours,

Walter H. Prescott

WHP/esg

Walter H. Prescott

Town of Stonington, Conn.

SELECTMEN'S OFFICE, TOWN HALL

Telephone Mystic JEfferson 6-9361

June 17, 1960

U. S. Army Engineer Division
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Attention: Gen. Alden K. Sibley, Division Engineer.

Gentlemen:

Ref: NEDGW
The Board of Selectmen have reviewed your plan for a hurricane protection barrier at Mystic, Connecticut crossing Sixpenny Island and deem it satisfactory.

In our letter of September 4, 1958, we stated that the Town would be unable and unwilling to pay 15%, that being our half sharedwith Groton of the 30%. unless other local interests, including the State, make a substantial contribution. We believe that the Town could be expected to join with them in making some contribution but in no case the full 15%.

Yours very truly,

David M. Johnstone

David M. Johnstone
First Selectman

DMJ:EFC

STATE OF CONNECTICUT
WATER RESOURCES COMMISSION
STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

February 21, 1958

Division Engineer
New England Division
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:

Reference is made to your letter of 28 January requesting comments on your proposed hurricane protection plan at Mystic, Connecticut

This proposed protection plan was presented to the Water Resources Commission at its meeting on February 3, 1958. The Commission, after considerable discussion, voted "approval of the general idea" and directed that a statement to this effect be made at the public hearing. In addition to this comment on the plan in general, you request comment on the possible participation in the cost by the State and local interests.

Although the federal policy on such participation has not yet been established by Congress, the Statutes of the State of Connecticut anticipate this type of project and under Sections N209 and N207 establish a basis of cooperation and participation by both this Commission and the Town Flood and Erosion Control Board. When federal policy is finally established it should require only minor changes if any in the Statutes.

At the present time there are no funds directly applicable for State participation in such projects. Your past experience should indicate that the State's attitude as expressed by both executive and legislative branches toward participation in improvement-protective projects has been progressive.

Very truly yours,

John J. Curry
Chief Engineer

JJC/jb

TOWN OF GROTON
INCORPORATED 1705
POQUONNOCK BRIDGE, CONNECTICUT

OFFICE OF
TOWN ENGINEER

TELEPHONE
HILLTOP 5-2178

September 2, 1958

Alden K. Sibley, Brigadier General U.S.Army
Division Engineer
U.S.Army Division, New England
Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Dear General Sibley:

Receipt is acknowledged of your letter of 26 August pertaining to hurricane survey report at Mystic, in the Town of Groton and Stonington, Connecticut wherein inquiries are made regarding the willingness and ability of local interests to meet the requirements which you are recommending.

It is my understanding that the present Town Administration is in favor of this proposal and that local participation by the Town of Groton can be assured provided a fair and equitable distribution of costs can be arranged between this town, the town of Stonington and the State of Connecticut.

Your kind offer to have a member of your staff visit Groton to discuss the matter of local cooperation is greatly appreciated and we will be grateful if such a visit may be arranged.

Sincerely yours,

George E. Kinmouth
Mayor of Groton

TOWN OF GROTON

INCORPORATED 1705

POQUONNOCK BRIDGE, CONNECTICUT

OFFICE OF
TOWN MANAGER

14 April 1958

Brigadier General Alden K. Sibley
Division Engineer
U.S. Army Engineer Division
New England
150 Causeway Street
Boston, 14, Mass.

Re: Hurricane Flood Protection of the
Mystic River, Connecticut Area

Dear General Sibley:

Receipt of your letter of April 4, 1958 is acknowledged.

I wish to advise you that the present administration of the Town of Groton has indicated favorable interest in this project, due in part to the protection which would be afforded to proposed town owned sewage collection and treatment facilities which we are considering for construction at a later date.

The protection which the proposed project will afford to properties other than town owned, has also been given favorable consideration.

The present town administration has indicated that limited participation in this project by the Town of Groton may be relied upon; however, at this time, discussion of the plan has not progressed to a point where definate and firm commitments have been made.

Very truly yours,

George E. Kinmonth

George E. Kinmonth
Mayor of Groton

GEK:HWK:mas